WRI INDONESIA

WORKING PAPER

THE GOVERNANCE OF RISK MANAGEMENT ON PEATLAND: A CASE STUDY OF RESTORATION IN SOUTH SUMATRA, INDONESIA

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EXECUTIVE SUMMARY

Highlights

- Peatland restoration is fundamental to prevent the risk of wildfires on degraded peatland. Governance plays a key role in supporting the effectiveness of peatland restoration.
- This study assessed critical aspects of the governance of peatland restoration in South Sumatra, Indonesia, from 2001 to 2019, using vulnerabilities and risk governance frameworks.
- Compared to the 2001–15 period, the number of peatland restoration projects increased in 2016–19, and some risk governance principles are in place.
- Nonetheless, some governance issues still exist in those peatland restoration projects, including uncertainties over data, lack of substantial coordination across stakeholders, excessive bureaucracy, and disintegrated restoration planning and implementation. These issues, which contribute to the quality and quantity of restoration projects, affect the outcomes of such projects, including their ability to prevent fires.
- Based on such findings, we suggest the adoption of a more detailed risk governance framework that involves understanding stakeholders' risk perceptions, establishing collective institutional arrangements, conducting a detailed risk assessment and evaluation for planning integrated restoration activities, implementing integrated landscape restoration, and monitoring and evaluating results.

CONTENTS

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Background

Between 1997 and 2015, Indonesia's devastating peat fires recurred due to the absence of strong policies and effective government for peatland restoration. During this period, the fires released 0.7 gigatons of carbon (GtC) emissions and exacerbated climate change. These hazards raised concerns about fire risk management on peatland. In 2016, the Government of Indonesia (GoI) established the Peatland Restoration Agency (Badan Restorasi Gambut; BRG) to support the Ministry of Environment and Forestry (Kementerian Lingkungan Hidup dan Kehutanan; KLHK) in scaling up peatland restoration projects as risk management efforts on the country's peatlands. Peatland restoration consists of activities such as soil rewetting, revegetation, and livelihood revitalization for peat-based communities. This program has been done in seven priority provinces, including South Sumatra. However, this restoration effort is hampered due to a poor governance system, which involves excessive bureaucracy and a lack of coordination among the BRG, KLHK, and local governments (Kartodihardjo et al. 2018). Due to this lack of coordination, restoration planning and implementation were not integrated within the peatland hydrological unit (PHU) as peatland landscape; this may influence the effectiveness and impact of peatland restoration activities (Kartodihardjo et al. 2018; KPRGSS 2018).

About This Paper

This study assessed critical aspects in the governance of peatland restoration in South Sumatra and its possible impacts. This province has experienced dynamic land-use change and fires on its 1.2 million hectares (ha) of peatlands since 1997. Our study draws on qualitative, spatial, and quantitative data; interviews with key stakeholders; direct observation; academic literature; experimental modeling; open data platforms; and reviews of policy and project reports. These data were analyzed with the help of theoretical frameworks describing the vulnerabilities and risk governance strategies (Giesen and Sari 2018; Renn 2017; Simon and Dooling 2013).

Vulnerabilities exist in political and material forms; thus, risk governance is needed. Political vulnerability is the inability of policymakers and stakeholders to deal with the complexity of governance that often results in poorly judged interventions and leads to unintended impacts, such as wildfires, on peatland. These impacts are known as material vulnerabilities. Governance reform, such as better data for planning, suitable institutional arrangements, and more coordination and enforcement in implementation, is needed to stop these vulnerabilities. These topics are included in the risk governance framework as a strategy to cope with the uncertainties inherent in complex socio-environmental actions such as peatland restoration. The risk governance framework covers aspects within the governance cycle—from planning to implementation and monitoring. It includes evaluating policy and governance practices that cause vulnerabilities, understanding stakeholders' perceptions of risk, creating robust institutional arrangements, assessing and evaluating risks, implementing risk management, monitoring, and communicating and coordinating all aspects.

By using those frameworks, we evaluated the governance of peatland restoration and developed recommendations for improving risk governance strategies to prevent fires. We offer a new direction for peatland stakeholders—such as the government, plantation companies, and civil society groups—to improve the performance of policies and peatland governance in Indonesia, and perhaps in other tropical countries, to support sustainable peatland management to mitigate climate change.

Key Findings

Although a few peatland restoration projects had been initiated in South Sumatra since 2001, they were small compared to the extent of peatland that was converted to concession areas between 2003 and 2010. The restoration activities during the 2000s were conducted by nongovernmental organizations (NGOs) and a government research institute in a few villages in two regencies, but the implementation was fragmented among different projects, actors, and designs and thus had low impact. Between 2003 and 2010, 320,000 ha of burned peatland was converted to oil palm plantations,[1] and 12 logging concessions[2] were established on 485,552 ha of peatland (KLHK 2018; Koh et al. 2011). This land conversion involved drainage activities that contributed to the continuing degradation of peatlands and increased their vulnerability to fires. In 2006–08, fires occurred on 301,454 ha of peatland. In 2011, the GoI issued a moratorium for business permits on peatland.

However, the moratorium was not fully implemented, and during the 2015 El Niño, fires recurred on between 117,367 and 144,410 ha of peatland in the province. This shows a high political vulnerability that contributed to recurrent material vulnerabilities.

In 2016, the government targeted 656,884 ha of peatland in South Sumatra for restoration by 2020, mostly located in concession areas. This target is part of the national peatland restoration program by the GoI. This program is facilitated by the KLHK and the BRG. Peatland restoration activities in concession areas are governed by the KLHK and concession holders; activities in nonconcession areas are managed by the BRG and provincial governments.

The authors found that peatland restoration projects that adapted a few risk governance principles increased significantly between 2016 and 2019. This is largely thanks to the national peatland restoration program, which improved policymakers' understanding of fire risk and the vulnerability of degraded peatlands. The GoI found that drainage activities further degraded peatlands, making them prone to fires and in need of restoration. The national restoration program brought more resources. The national and provincial government worked with NGOs, communities, and concession holders to conduct a risk assessment and evaluation to help them plan restoration activities over wider areas.

However, some critical issues were found in the governance of peatland restoration, particularly in 2017–18. These issues are considered political vulnerabilities in the practice of peatland restoration in the province, and they contributed to material vulnerability during the 2019 El Niño year. Interactions and feedback among the stakeholders involved in those issues are set out in Figure ES-1.

First, the effectiveness of restoration planning and implementation was impacted by a lack of both accurate risk assessment and effective communication among peatland restoration stakeholders. A detailed risk assessment is required to understand the priorities and location for peatland restoration, and accurate, updated peatland data is imperative. Unfortunately, South Sumatra lacked such data in 2017. This issue seriously affected the overall result of restoration activities and was exacerbated by different perceptions and poor communication between the BRG and provincial governments. This hampered the implementation of more than 5,000 restoration activities in 2017. In 2018, although the peat data accuracy was addressed, necessary restoration activities did not occur in some peat areas. Also, a lack of standard enforcement in implementation led to technological issues and mistargeted aid. By the end of 2018, peatland restoration implementation in nonconcession areas achieved about 10 percent of the provincial target.

Second, restoration progress has been slow in concession areas due to excessive bureaucracy, and peatland continues to be converted to concessions. Restoration in concession areas requires concession holders to go through a lengthy process with the KLHK. Although the BRG had provided technical assistance about restoration to concession holders, it was not enough to speed up the progress of restoration because implementation relies on approval by the KLHK. Besides, there was lack of substantial integration between the BRG's role in providing technical assistance and the KLHK's authority to approve concession holders' restoration plans. As of 2018, the KLHK had yet to approve any official restoration plans for concession holders in South Sumatra; nonetheless, some concession holders were moving ahead with restoration activities. Meanwhile, between 2015 and 2018, other concession holders continued to convert peatland[3] (78,607 ha/year[4]) to oil palm plantations (YMB 2020) despite the moratorium policy on peatland conversion. Weak enforcement of the moratorium policy contributed to continued peatland conversion. This sustained the drivers of peatland degradation in the province.

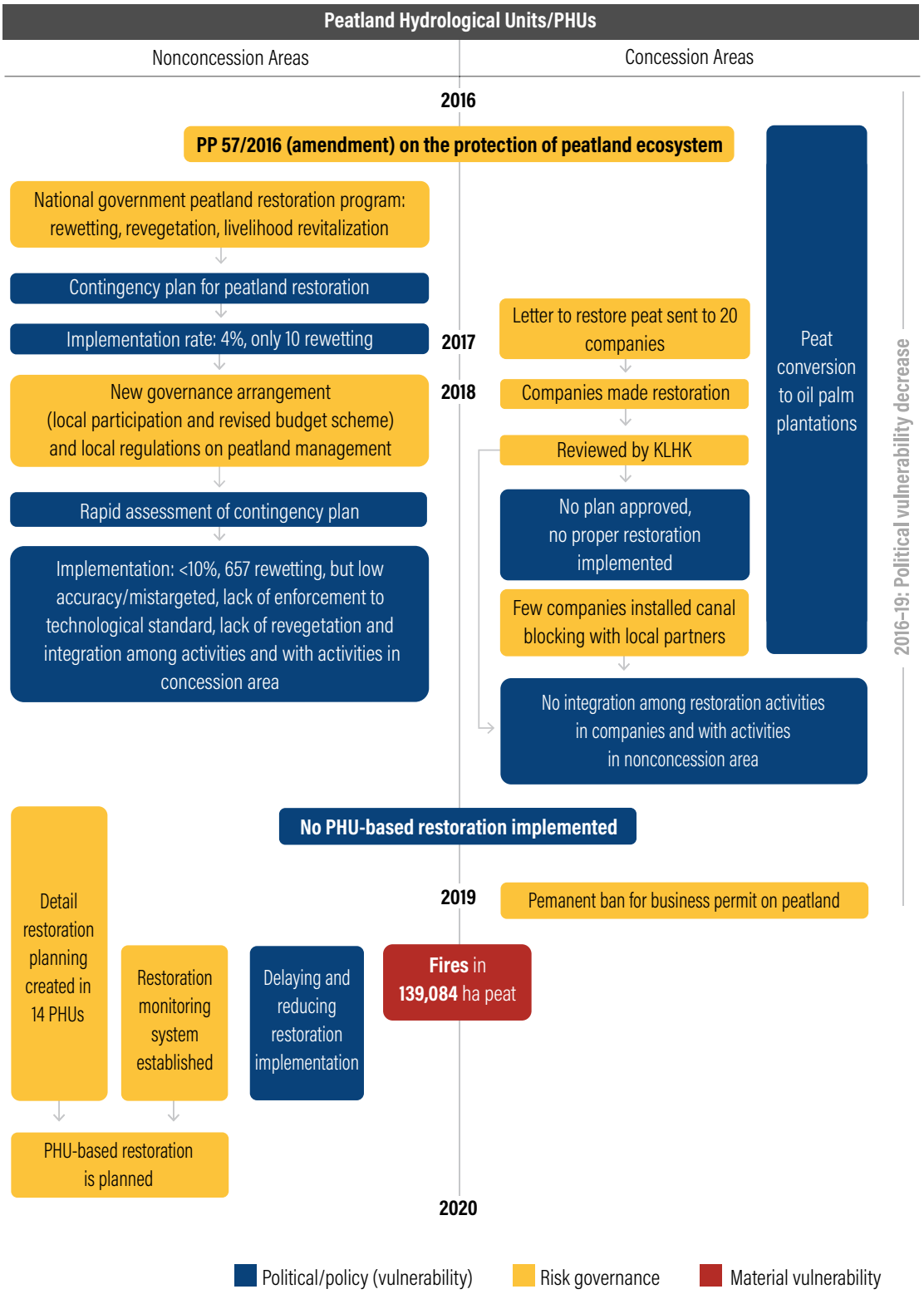
Third, there was a lack of collective action for conducting landscape restoration that covers concession and nonconcession areas. This was caused by the absence of any substantial coordination among peatland restoration stakeholders to plan and implement an integrated restoration in the same landscape/PHU. Integration between restoration in villages and concession areas was also lacking. This might have been caused by the structure of the institutional arrangement, which divided restoration responsibility between concession and nonconcession areas, in different organizations, without a proper coordination mechanism.

Those three governance issues are considered political vulnerabilities where policymakers and stakeholders have yet to deal with the complexity of restoration governance. Overall, these issues have contributed to low target achievement and poor implementation of restoration. They reduced the effectiveness of the restoration program and led to unintended impacts during the El Niño year. During the El Niño, the dry season was three to four months longer, and it made unrestored peatlands more prone to wildfires. These situations brought material vulnerability.

These political vulnerabilities resulted in greater peatland fires during the 2019 El Niño. Between 139,084 and 174,341 ha of peatland burned, emitting 0.049–0.062 GtC (KLHK 2020; UMD n.d.). About 70 percent of fires occurred in new areas. Seventy-six percent of these newly burned peatlands were found in concession areas that included new concessions converted in 2015–18. Another 30 percent were located in areas that also burned in 2015–18. These burned areas included some areas where restoration activities were planned and/or implemented.

These findings suggest that peatland conversion to concessions must cease, restoration in concession areas must be accelerated, and governance must be improved to increase the impact of restoration efforts. Some improvements have been made. In 2018–19, with an NGO consortium consisting of World Resources Institute Indonesia, World Agroforestry, and Wetlands International Indonesia, the BRG arranged detailed annual restoration plans for 14 PHUs in South Sumatra. These plans include stakeholder analysis in the PHUs. This helped to more accurately implement restoration in the province in 2019. In addition, the BRG and its partners also established an online monitoring platform[5] to measure the progress of restoration activities and evaluate their impacts. These actions have adapted more aspects within the risk governance framework.

Figure ES-1 | **The Governance of Peatland Restoration in South Sumatra, 2016–19**



Note: KLHK = Kementerian Lingkungan Hidup dan Kehutanan (Ministry of Environment and Forestry); PP = Peraturan Pemerintah (Government Regulation).
Source: WRI Indonesia authors.

Recommendations

To further improve governance of peatland, a more detailed risk governance strategy that considers both biophysical and socioeconomic aspects of the ecosystem is needed. This strategy must reflect specific functions, such as detailed risk assessment, monitoring tools, effective risk communication, and deliberative participation. It aims to develop a structure that is better suited to cope with fire risk from degraded peatlands and the increased frequency of El Niños. This risk governance strategy should involve multiple stakeholders in the decision-making process to enable the creation of mutual agreement procedures/mechanisms and to support knowledge/technology transfers.

The risk governance strategy can help policymakers and stakeholders cope with multiple uncertainties, such as technoscientific knowledge, institutional strategy, and politics in peatland restoration. This approach can address institutional issues and disjointed restoration activities in South Sumatra. It could also be applicable to other provinces in Indonesia and other tropical peatland countries. This more detailed strategy of risk governance can be implemented through the following actions (Renn 2017), as shown in Table ES-1.

Table ES-1 | Governance Strategies for Restoring Degraded Peatland

Goal	Action	Responsible Actor
Find a strategy to deal with different interests	Understand the perception of stakeholders within a PHU of landscape restoration	(Local) government
Organize collective actions in planning and implementing integrated landscape restoration, using stakeholder analysis in the PHU-based restoration plan	Establish a multilevel institutional arrangement in and between each landscape, with clear task divisions, resource allocation, and coordination mechanisms	Provincial/regency/landscape coordinator
Prioritize the most vulnerable peatlands to be restored, such as (former) concession areas	Reassess and evaluate (fire) risk based on real-time peatland data after annual fires and El Niño forecast/ outlook	Stakeholders in degraded peatlands
Guide connectivity among restoration activities	Prepare a detailed integrated restoration plan yearly, for all peat landscapes/PHUs	Stakeholders in the landscape
Handle risks in most degraded peatlands	Implement integrated landscape restoration and ensure compliance with standard enforcement in each activity	Stakeholders in degraded peatlands
Adaptive learning for sustainable peatland management	Conduct inclusive monitoring and evaluation, using information systems and community participation	Stakeholders in the landscape and (local) government

Note: PHU = peatland hydrological unit.
Source: WRI Indonesia authors.

Consistent political will and effective communication will be necessary for conducting the abovementioned actions. (National) policymakers must consider diverse strategies and the institutional capacity of local organizations, ensure knowledge/ technology transfers, and respect cultural/political sensitivity in different locations. All stakeholders must communicate effectively (e.g., by clearly stating the results of detailed risk assessments, specifying potential risks) in order to make a restoration plan acceptable and implemented collectively.

1. INTRODUCTION

Indonesia is home to the world's second-largest tropical peatland area, accounting for about 36 percent of the total area (Page et al. 2009a; Warren et al. 2017). Since the 1980s, extensive concession areas have been granted, converting the peatland ecosystem into a canalized and drained landscape (Barber and Schweithelm 2000).

Persistent and intensive drainage for logging, plantations, and community agriculture has caused extensive peatland drying and degradation (Cattau et al. 2016; Page and Hooijer 2016). These conditions, and the absence of consistent policy measures for sustainable peatland management, contributed to the fires that burned 1.4 million hectares (ha) of peatland in 1997 and 0.4 million ha during the 2015 El Niño in Indonesia (Budiman et al. forthcoming; Huijnen et al. 2016; Tacconi 2016; Varma 2003).

A peat fire is considered a systemic risk that denotes the "embeddedness" of other risks to human health, ecology, climate, and socioeconomic consequences. This systemic risk is at the crossroads between policy-driven actions (plantations), socioeconomic development (community agriculture), and natural events (El Niño) (Renn 2017). The fires in 1997 and 2015 released 0.7 gigatons of carbon (GtC) emissions, afflicted thousands with respiratory diseases, and led to financial losses[6] amounting to between US$1.62 and $2.7 billion (Page and Hooijer 2016; Tacconi 2003). Tropical peatland fires thus represent a significant global systemic risk, and both national and regional humanitarian, environmental, and economic threats (Page and Hooijer 2016).

To help prevent future peatland fires and to introduce a new risk management strategy for peatland, Wetlands International Indonesia (WII), in partnership with local NGOs and local governments, initiated the first tropical peatland restoration project in 2001 (Noor and Heyde 2007). In 2016, the idea was adopted by the Government of Indonesia (GoI) by establishing peatland restoration programs. The GoI utilizes three main peatland restoration activities: soil rewetting, revegetation, and livelihood revitalization (BRG 2016). These activities are expected to handle the systemic risks from peat fires.

Restoration starts with the rewetting activities of canal blocking and canal backfilling, which are the most important part of the hydrological aspect. Precise canal blocking/backfilling can raise the water table[7] (Jauhiainen et al. 2008b). These activities must be implemented in the entire peatland ecosystem within the peatland hydrological unit (PHU), which is an integrated water management system, to purposefully rewet peatlands (Harrison et al. 2020).

After soil rewetting, revegetation is needed to complete the biophysical restoration of peatland. Rural livelihoods must then be revitalized to reduce community pressure on rewetted peatland. The GoI's Peat Care Village (Desa Peduli Gambut; DPG) program[8] can educate the village community about peatland restoration.

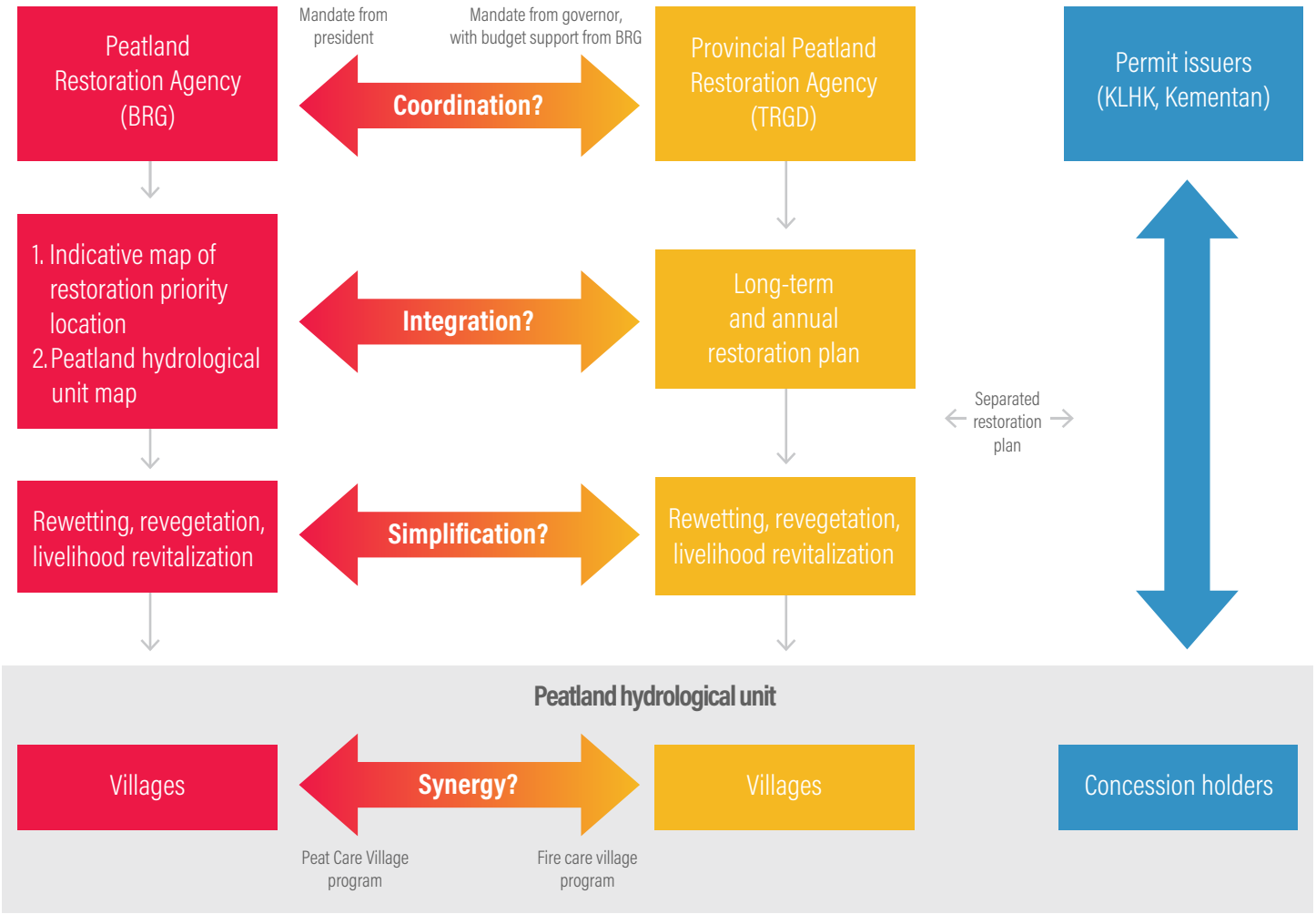
Those restoration activities will help support the rewetting of peat to near-natural levels and establish a protective vegetation cover. By reducing desiccation, peatlands will be less vulnerable to fire risk (Giesen and Sari 2018).

Peatland restoration programs are facilitated by the Peatland Restoration Agency (Badan Restorasi Gambut; BRG) and the Ministry of Environment and Forestry (Kementerian Lingkungan Hidup dan Kehutanan; KLHK). The BRG facilitates multistakeholder participation in governing peatland restoration projects in nonconcession areas across seven priority provinces (BRG 2016): Central Kalimantan, Jambi, Papua, Riau, South Kalimantan, South Sumatra, and West Kalimantan. The KLHK is responsible for overseeing how concession holders conduct peatland restoration.[9]

However, the effectiveness of restoration programs and the progress in concession areas is questionable (BRG 2019c; ICRAF 2019). By 2018, the BRG claimed that it had carried out rewetting and/or livelihood revitalization on about 679,000 ha of peatland ecosystems in the seven priority provinces (Pantau Gambut n.d.). Yet about 90 percent of the areas targeted for restoration were still drained and had low water tables during the 2019 El Niño,[10] and fires still occurred in some areas (BRG 2019c). South Sumatra is one of the provinces that experienced large fires on its peatlands. This shows that peatlands remain vulnerable to fire risk.

A previous study in South Sumatra found that the governance of these restoration programs hindered their progress. Governance issues included a lack of substantial coordination and lingering bureaucracy in restoration planning and implementation (Kartodihardjo et al. 2018).[11] Figure 1 shows that the various institutions responsible for peatland restoration, such as the BRG, the KLHK, the provincial government, and concession holders, have different approaches to planning restoration and tend to simplify the detailed implementation of restoration activities. As a result, restoration activities within each PHU are not well connected, and PHU-based restoration is not yet being implemented (KPRGSS 2018). These governance problems are seen as a political vulnerability that responds incorrectly to the need to restore degraded peatland in an integrated manner. *Political vulnerability* refers to the broader political, and economic conditions, socio-environmental changes, and complex structures of governance that influence material conditions and community experiences (Simon and Dooling 2013). Political vulnerability in the peatland restoration program generates/reinforces the vulnerability of degraded peatlands to fire.

Figure 1 | **The Lack of Coordination and Integration in Governing Peatland Restoration**



Note: BRG = Badan Restorasi Gambut (Peatland Restoration Agency); Kementan = Ministry of Agriculture; KLHK = Kementerian Lingkungan Hidup dan Kehutanan (Ministry of Environment and Forestry); TRGD = Tim Restorasi Gambut Daerah (Provincial Peatland Restoration Agency). See Section 4.2 for more information about TRGD.
Source: Kartodihardjo et al. 2018.

Governance is one of the key drivers of successful peatland restoration efforts. Renn (2017) and Simon and Dooling (2013) suggested that understanding political vulnerability within the governance cycle and introducing a risk governance framework can make socio-environmental actions, such as peatland restoration, more effective. Risk governance offers a holistic approach to risk assessment, risk handling, and investigating interdependencies within systemic risks (Renn 2017). This can improve the effectiveness of restoration programs to decrease peat vulnerability to fires (Jong 2019).

2. STUDY OBJECTIVES AND APPROACH

Twenty percent of Sumatra's peatland area is located in the province of South Sumatra. Since the 1980s, the province's 1.2 million ha of peatland have undergone extensive changes (BRG 2017). Forty-five percent of peatland area in South Sumatra is situated in nonforest area, 40 percent in production/plantation forest (including industrial forest), and 13 percent in a protected forest (national parks and wildlife reserves). South Sumatra thus provides a microcosm of peatlands in Indonesia.

This study aims to explore the detailed political vulnerabilities in the governance and management of peatland ecosystem restoration in South Sumatra and develop a strategy to improve performance. The result will help peatland agents—government officials, policymakers, civil society organizations, citizens, and the private sector—understand how the vulnerabilities in the policies and governance of risk management on peatland have unfolded on Indonesia's peatland over the last 20 years and how to stop the cycle by changing current governance practices.

By incorporating lessons learned from the case study of current peatland governance in South Sumatra into the conceptual framework developed for this study (see Section 2.1), we provide an alternative governance model to guide tropical peatland restoration management. We hope this model will be used by stakeholders and policymakers to improve the quality of planning and implement more sustainable and resilient peatland restoration management. The adoption of this governance framework could reduce vulnerability, environmental risks, and fire hazards on peatlands and surrounding areas.

2.1. Conceptual Frameworks

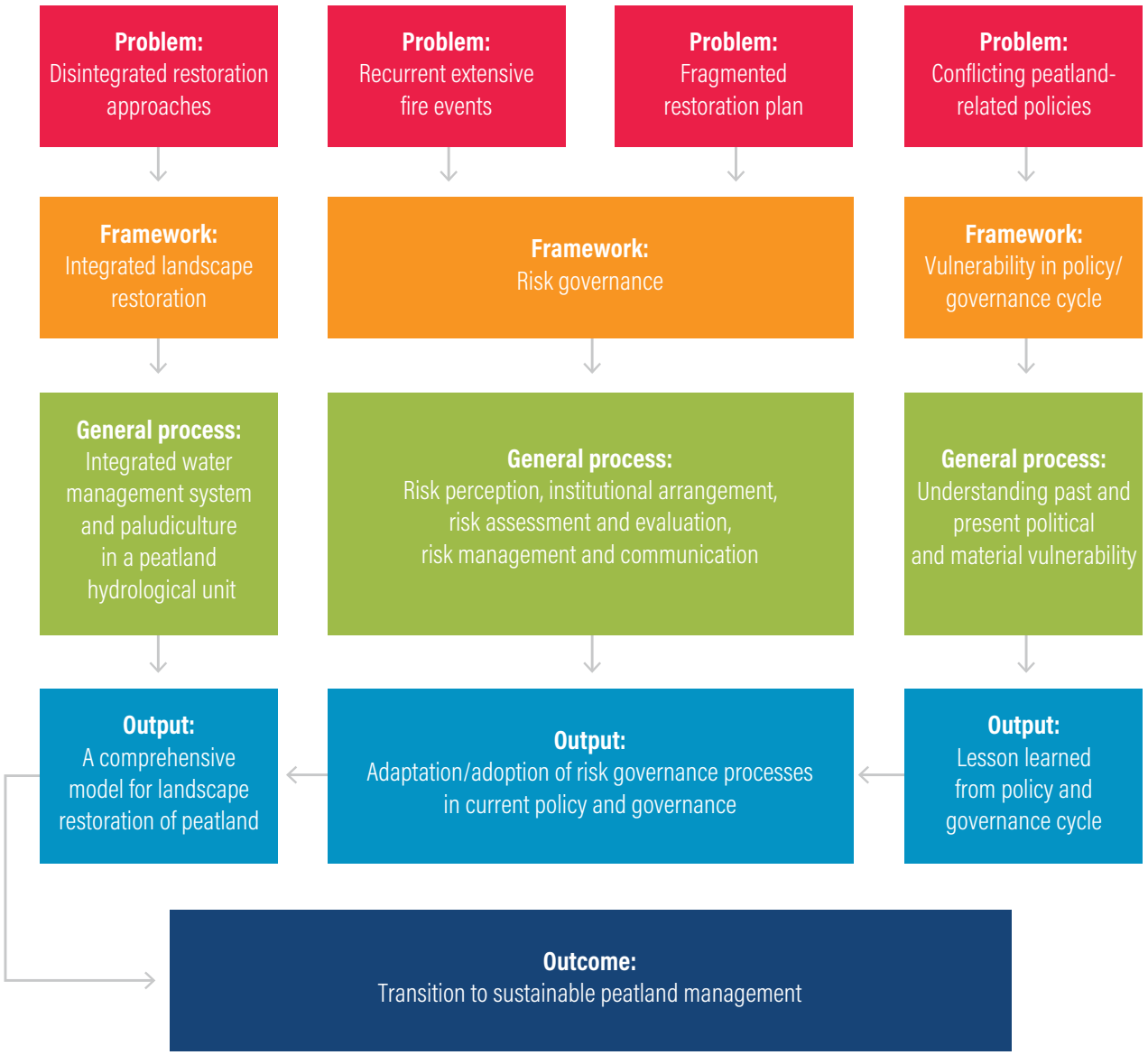
This study combines three theoretical frameworks: the cycle of vulnerability (Simon and Dooling 2013), risk governance (Renn 2017), and landscape restoration of the peatland ecosystem (Giesen and Sari 2018). The cycle of vulnerability theory analyzes how political vulnerability (a lack of knowledge by policymakers about the science of sustainable peatland management and the absence of ground-truthed information) can influence the quality of policies and on-the-ground impact (material vulnerability). Policymaking needs better data, institutions need reform, and implementation needs more coordination and enforcement.

Risk governance on peatland includes landscape-level peatland restoration that combines three steps: (i) rewetting peat soil in a coordinated manner to create an integrated water management system, (ii) using the principles of paludiculture[12] to revegetate peatland, (iii) and revitalizing the livelihoods of local communities and regulating the practices of commercial concession holders to reduce anthropogenic pressures (Nursyamsi et al. 2016; Sayer et al. 2013). Appendix A provides more details about these frameworks and explains why they should be employed.

2.1.1. The Framework of the Study

The framework of this study involves three areas of synthesis: (i) the role of policy and governance structures and decision-making processes in increasing or reducing vulnerabilities in peatland management, (ii) the temporal and spatial dynamics of vulnerability, and (iii) the adoption and/or adaptation of risk governance aspects, including landscape restoration. We examine linking mechanisms[13] between policy and governance practices, the implementation of restoration activities as policy outputs and their impacts or outcomes, such as biophysical changes on peatland areas and their ability to resist fire spread (Figure 2). The types of linking mechanisms/actions are discussed in Appendix B.

Figure 2 | **Conceptual Framework to Transform the Governance of Risk Management on Peatlands**



Source: WRI Indonesia authors.

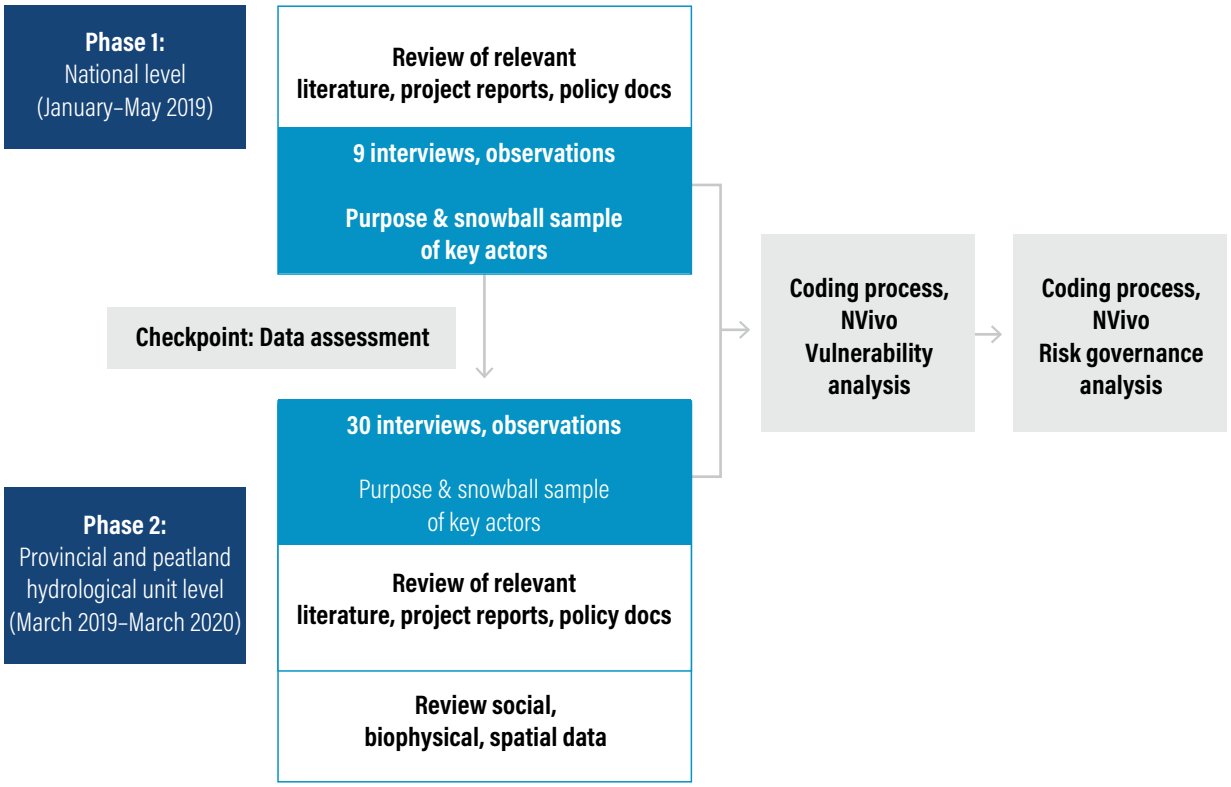
3. METHODOLOGY AND STUDY AREA

Activities and efforts to restore peatlands in South Sumatra have been conducted by the national and provincial governments, NGOs, and concession holders since 2001. To support the conceptual framework of this study, we collected spatial, qualitative, and quantitative data on both biophysical and social aspects in two phases (Figure 3). The first phase involved a review of literature and documents, semistructured interviews, and observation at meetings, where we gathered information about the governance of peatland restoration activities in South Sumatra that are managed by the national government.

A total of nine semistructured interviews were conducted with key national stakeholders from January to May 2019 (see Appendix C).

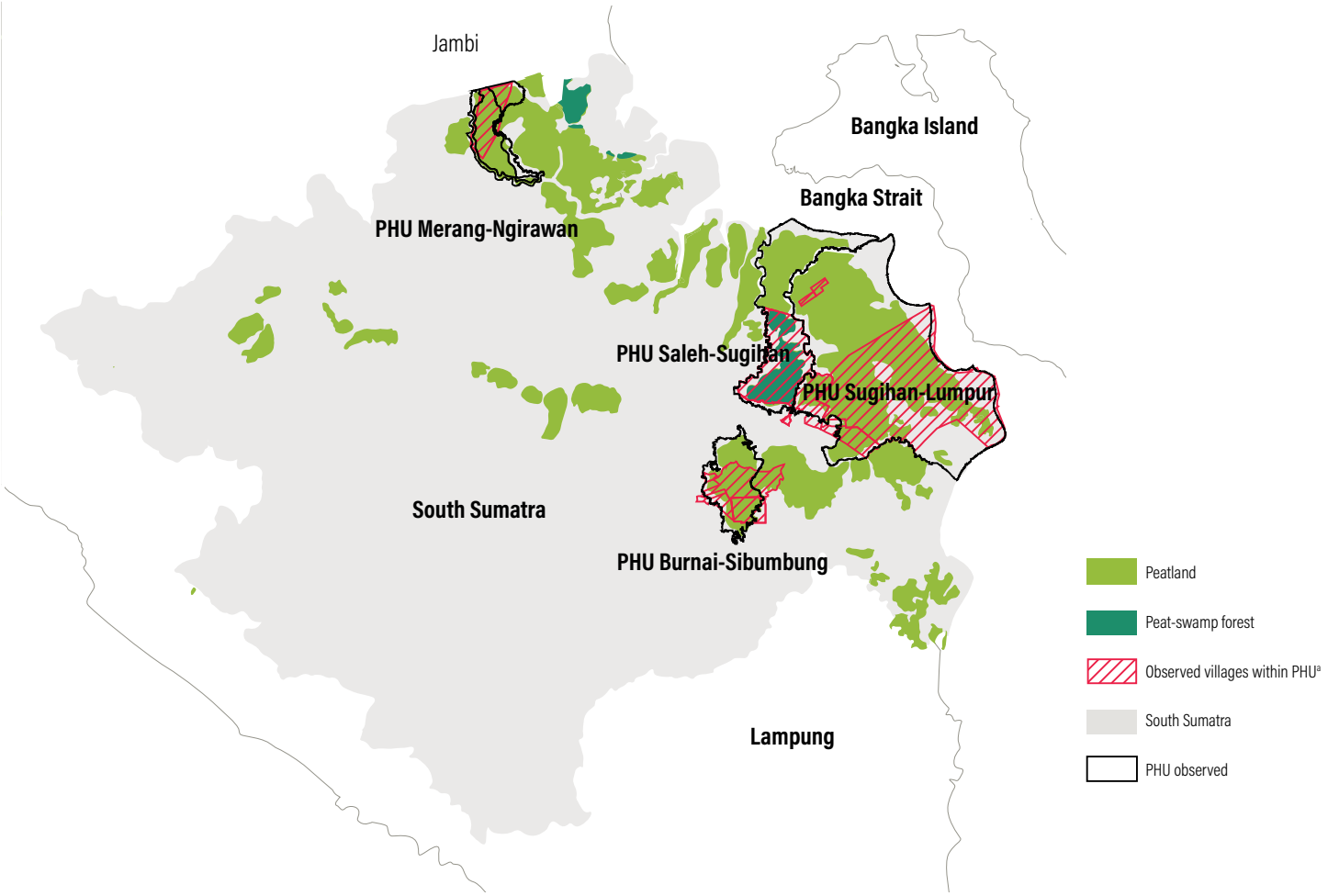
The second phase was continued between March 2019 and March 2020, with further interviews, literature and document reviews, and observation at meetings about the peatland restoration in South Sumatra. We selected four PHU samples in the province (Figure 4), then analyzed and synthesized findings from those PHUs and confirmed with provincial stakeholders whether they aligned with experience in other PHUs in South Sumatra. The second phase of data collection was done in four steps (Appendix L).

Figure 3 | **The Data Collection and Analysis Process**



Source: WRI Indonesia authors.

Figure 4 | **Study Area**



Note: PHU = peatland hydrological unit.
[a] The boundaries of observed villages cover the land managed both by the villages and concession holders.
Source: WRI Indonesia authors.

3.1. Interviews and Document Review

The interviews utilized the purposive and snowball sampling technique to select key persons from key institutions in the governance cycle (planning, implementation, and monitoring and evaluation) of peatland restoration and related stakeholders (see Appendix C). The topic list from the conceptual framework was used to guide the interviews. Our emphasis was on questions about the linking mechanisms between political vulnerability and material vulnerability.

During peatland-related meetings, we also collected information from relevant stakeholders, such as governments, concession holders, NGOs, and communities (see Appendix D). During each interview and meeting observation, we requested policy documents and program reports from each stakeholder as well as documentation regarding restoration activities. These were systematically reviewed for data verification. We also undertook a literature review of relevant research papers on peatland management and restoration in South Sumatra to deepen the analysis. Reliable national and regional media were monitored to support additional verification.[14]

3.2. Field Observations and Measurements

In selected villages, we conducted field observations and measurements to evaluate the accuracy of the restoration plan and monitor the indicative impact of restoration implementation.

First, ground truthing was done to ensure that the restoration plan was correct and that it was being implemented on peatland.[15] We measured the bulk density of soil by excavating a quantity of soil using a ring sampler, drying and weighing it, and determining the volume of the excavation in a soil laboratory (Grossman and Reinsch 2002). Soil is categorized as peat when it has bulk densities around 0.15 grams per cubic centimeter (g/cm^3) at depths of 15–30 cm (Andriesse 1988; Warren et al. 2012).

Second, to measure the progress of the restoration activities, we used field measurement and experimental modeling to analyze the indicative impact of physical restoration activities, such as canal blocking and canal backfilling, on peatlands. We used water logging technology, which measures the following parameters: topography, rainfall, meteorological data, groundwater flow, surface flow, land-use vegetation, and subsidence/flooding. Sampling for this field measurement was done by selecting 10 location points near the canal blockings in each PHU.

3.3. Data Analysis

All collected data were organized depending on whether they were transcribed (interviews), scanned (printed document review), or typed up (other field notes). Later, the data were coded based on the aspects in the conceptual framework, and NVivo software was used to provide more detailed content analysis.

The first coding session involved the interview transcripts, policy documents, and program or project reports. It analyzed vulnerability in the governance cycle of peatland management, particularly on restoration. The second session of coding analyzed risk governance phases in the governance cycle of peatland restoration. A third coding session then analyzed the linking mechanisms between political vulnerability in peatland governance with material vulnerability on the ground. This analysis was combined with the results from field measurements and spatial analysis. Relationships between aspects were carefully reviewed and triangulated with the interview transcripts, policy documents, program/project reports, and spatial data. This relationship analysis helped us to categorize the periods of the governance cycle based on its degree of vulnerability.

The results of the analysis were presented at the expert discussion for verification and feedback. The expert panel was presented with a series of questions about the most important findings, and their responses were used to deepen the analysis. These experts were chosen based on their related work experiences on peatland restoration during the last five years.

4. RESULTS

The following sections present findings on the risk governance of peatland management in South Sumatra during two distinct periods: 2001–15 (Table 1) and 2016–19 (Table 2). This division was based on the degree of vulnerability during each period. There was significant difference in the governance of peatland restoration in 2001–15 compared to 2016–19. Before 2001, there was no peatland restoration in the province. The findings below are explained following the historical timeline of events.

4.1. Vulnerability in the Governance of Risk Management on Peatland, 2001–2015

In 1990, the GoI issued Presidential Decree No. 32 to categorize peatlands deeper than 3 meters (m) and located in upstream locations[16] as protected areas. However, a lack of reliable peatland data and strong political and economic demand for natural resource exploitation led to the continuous issuance of concession permits in protected peat areas (Barber and Schweithelm 2000; Budiman et al. forthcoming). Peatland continued to degrade, and in the 1997 El Niño year, fires burned about 700,000 ha of peat and swamp forest in South Sumatra (Barber and Schweithelm 2000; Suradisastra et al. 2010; Wijaya 2019b). This event became a turning point for the emergence of restoration projects.

4.1.1. Fragmented and Project-Based Restoration Activities

After the fires of 1997, the first pilot peatland restoration project[17] was initiated by Wetlands International Indonesia (WII) in partnership with a local NGO (Wahana Bumi Hijau). The project ran from 2001 to 2007 in the degraded area in the Merang-Kepayang peat swamp forest[18] in the Banyuasin and Musi Banyuasin (Muba) Regencies (Noor and Heyde 2007). The two NGOs conducted a risk assessment for planning restoration activities in the area. It resulted in two types of restoration activities being implemented: soil rewetting, achieved by permanently blocking two canals[19] within a 1 ha peatland area; and incorporating peatland conservation into the policy of village governments and the Muba Regency (Suradisastra et al. 2010).

The WII restoration project cooperated with the South Sumatra Forest Fire Management Project (SSFFMP) that was implemented from 2003 to 2008 in the same regencies of Banyuasin, Muba, and Ogan Komering Ilir (OKI). Villages[20] in these regencies were the worst affected by the 1997 fires (SSFFMP 2007; Wijaya 2019b). The SSFFM project aimed to reduce the community pressure to clear new peatlands by introducing alternative livelihoods. These SSFFMP and WII activities are considered risk management.

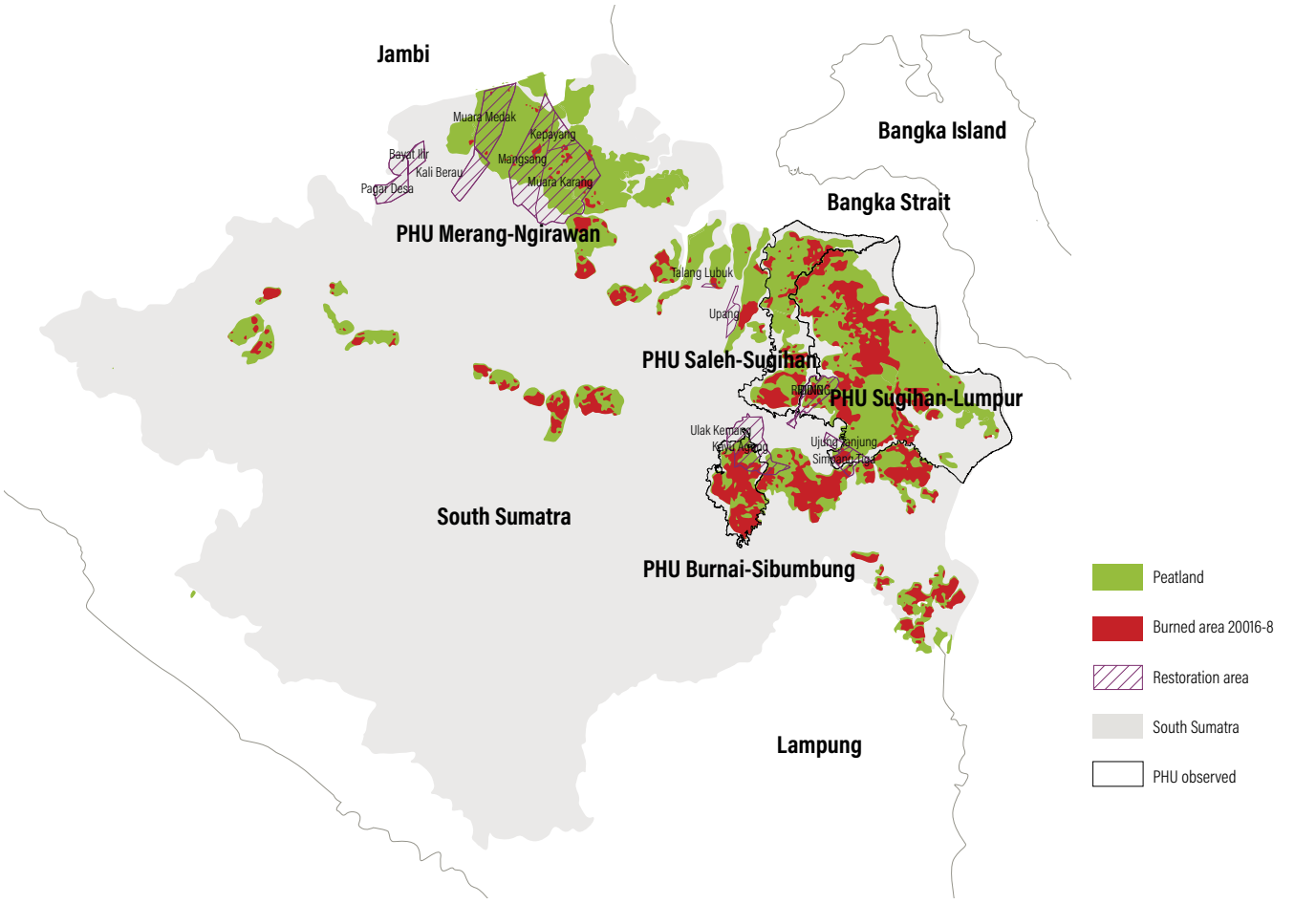
The SSFFMP was followed up with the Merang REDD Pilot Project (MRPP), in the same location of Merang-Kepayang (Wijaya 2019b). This project focused on analyzing threats to forest cover in the peat swamp forest, assessing biodiversity in the peat dome area, and estimating carbon stocks in the peat swamp forest area (MRPP 2009). Neither the SSFFMP nor the MRPP carried out comprehensive restoration activities in the peatland ecosystem of Merang-Kepayang(SSFFMP 2007; Wijaya 2019b). These projects did not contribute directly to restoring the peatland ecosystem in the area, but they helped to provide peatland data that supported restoration activities during the next period (Wijaya 2016). This action is considered risk assessment.

Unfortunately, early activities were relatively ineffective. Peatland restoration was fragmented across several villages. Funding resources were scarce due to the absence of supporting regulation, and knowledge about landscape-based restoration was still limited. At that time, the concept of the PHU did not yet exist. The idea of restoration was not seriously adopted by local governments due to a lack of both resources and political will (SSFFMP 2007). As a result, peatland restoration activities were not scaled up to other degraded peatlands in South Sumatra.

4.1.2. Converting Peatlands to Plantations

While NGOs did restoration, the GoI granted business permits on peatlands for industrial forest plantations and for oil palm plantations from the early 2000s (Koh et al. 2011; Lee et al. 2014). By 2010, 320,000 ha of the province's peatlands had been cleared for 16 oil palm plantations, and 12 logging concessions had been granted on 485,552 ha of peatland. South Sumatra placed third in terms of peatland conversion, after Riau and Central Kalimantan (Koh et al. 2011). These plantations expanded the need for drainage canals in the area (Akbar 2008), which undermined restoration efforts. Peatlands continued to dry and degrade. In 2006–8, 301,454 ha of peatlands were burned in the province, including 14,818 ha in villages in or near the restoration and conservation area (Figure 5).

Figure 5 | **Peat Fires in South Sumatra, 2006–2008**



Note: PHU = peatland hydrological unit.
Source: WRI Indonesia authors.

After the fires, another restoration project emerged, together with another peatland conversion, creating the cycle of vulnerability.

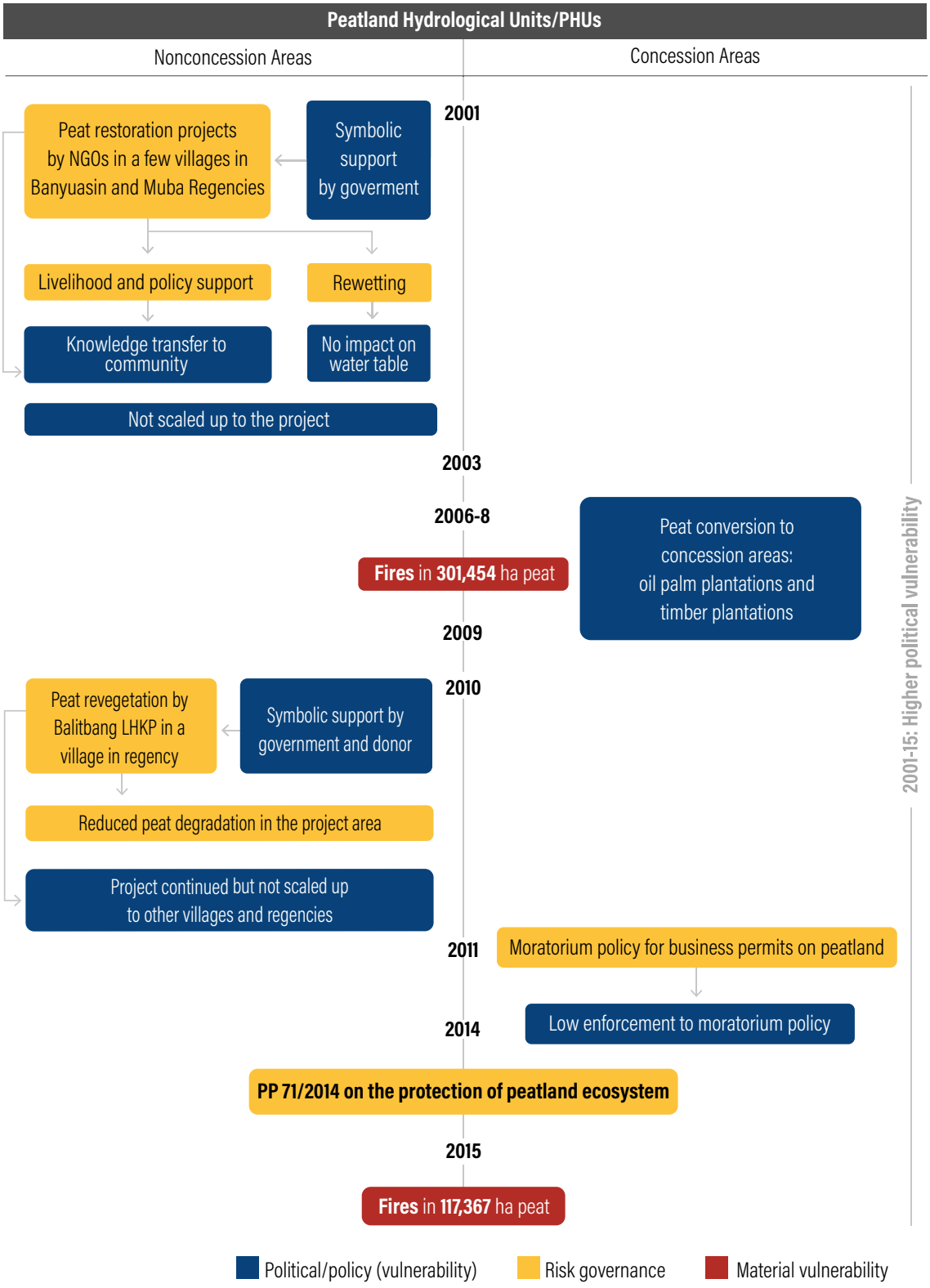
4.1.3. Key Vulnerabilities in Peatland Governance, 2001–2015

The period 2001–10 can be regarded as an early peatland restoration era. Figure 6 shows that the governance of peatland restoration activities was fragmented across different areas and different efforts to rewet peat, introduce alternative livelihoods, and carry out revegetation. Risk assessment and risk management were done at the project level, so implementation was inconsistent. Blocking canals and introducing alternative livelihoods in a few villages was not adequate to rewet peatland and reduce human pressures on it.

A lack of serious support from higher government levels squandered the opportunity to scale up restoration projects. This also contributed to the inability of the restoration projects to build the capacity of local communities to continue restoration efforts, so they continued to rely on project assistance.

Figure 6 and Appendix I show how actions in the governance process of risk management on peatlands transformed political vulnerabilities into material vulnerabilities between 2001 and 2015 in the province.

Figure 6 | **Vulnerabilities in the Governance of Project-Based Peatland Restoration**



Note: NGO = nongovernmental organization.
Source: WRI Indonesia authors.

Meanwhile, business permits for concession holders and community slash-and-burn agricultural practices continued in South Sumatra's peatlands; therefore, they remained vulnerable to fires.

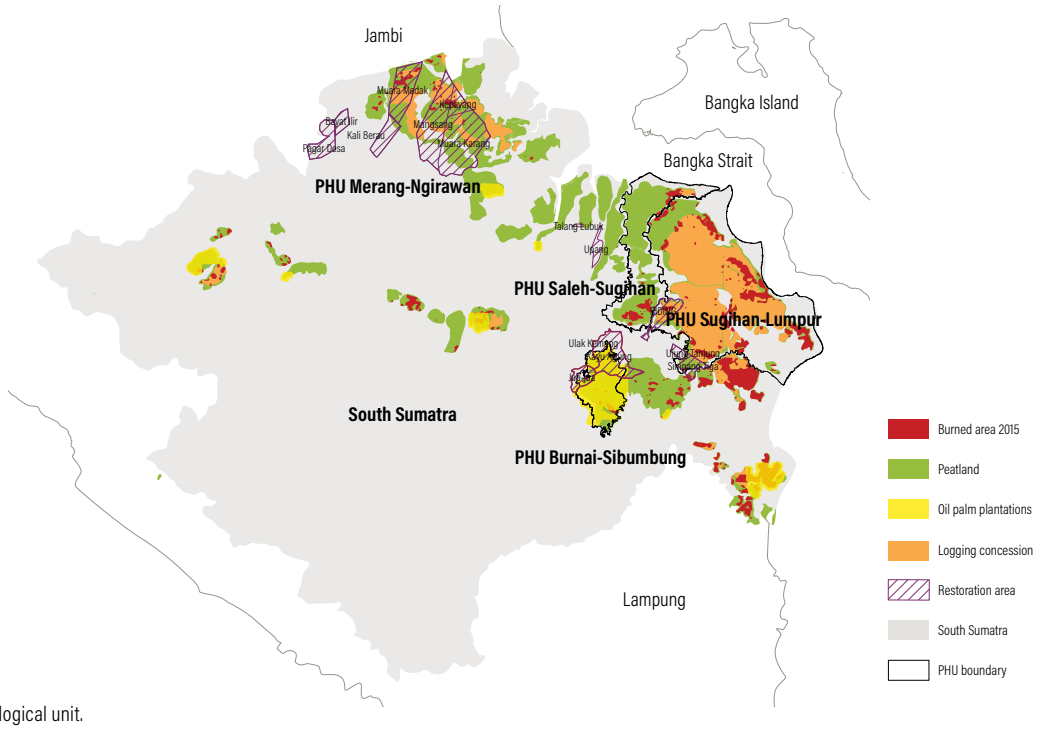
In 2011, the GoI issued a moratorium for business permits on peatlands. The map for the moratorium was released that same year and was revised every six months during the following years (Enrici and Hubacek 2016; KLHK 2019b). However, the moratorium was not fully implemented—some permits were still granted due to the unreliability of peat data and ignorance/corruption of some government actors and companies (Zuraya 2019). Thousands of hectares of peatlands are estimated to have been used and degraded by commercial activity during the moratorium era (Sumarga et al. 2016).

The abovementioned problems highlight a number of political vulnerabilities that hampered the impact of restoration during this period:

- Poor coordination across implementing agencies (NGOs and the government research institute) hindered adaptive learning across restoration projects.
- Poor understanding of sustainable peatland management and the absence of supporting regulation (Pratama 2015) resulted in a lack of funding and political will by the local governments to scale up restoration projects.
- The national government had a policy of granting permits for oil palm and industrial forest plantations before 2011 and did not strongly enforce the moratorium policy.[21] This undermined restoration,[22] and as the area of degraded peatland increased, the need for restoration also grew.

These weaknesses contributed to devastating peat fires in 2006–8 and in 2015, and the consequent material vulnerability: greenhouse gas (GHG) emissions, haze, health issues, and economic loss (BNPB 2016). The 2015 El Niño triggered devastating fires in vulnerable peatlands in South Sumatra. Fires burned between 117,367 and 144,410 ha of peatland in the province (KLHK 2020; UMD n.d.). About 6,580 ha of burned peatlands were located in the villages in or near former restoration and conservation project areas in the Banyuasin, Muba, and OKI Regencies; another 13,061 ha burned in oil palm plantations; and 67,846 ha burned in logging concessions (Figure 7). The fires created a haze that contributed to lung and respiratory disorders affecting 30,000 people (Antara News 2015). The World Bank estimates that the 2015 fires cost South Sumatra at least US$2.57 billion (Glauber et al. 2016).

Figure 7 | **Burned Peatlands in South Sumatra, 2015**



Note: PHU = peatland hydrological unit.
Source: WRI Indonesia authors.

4.1.4. Signs of Change

Despite the vulnerabilities, the 2001–15 period marks a turning point in understanding risk assessment and management on peatlands by local stakeholders. Previously, the concept of peatland restoration was unknown in South Sumatra. By conducting restoration projects, the WII and the Palembang Environment and Forestry Research and Development Center (Balai Litbang Lingkungan Hidup dan Kehutanan Palembang; Balitbang LHKP) helped transfer knowledge to local NGOs and communities about canal blocking, revegetation, alternative livelihoods, and mainstreaming peatland conservation in the village policy.

In 2014, the GoI issued Government Regulation No. 71/2014 on the protection of peatland ecosystems. Commercial plantations must ensure the water table does not fall 0.4 m below the surface of the peat. The regulation, however, coincided with the fires of the 2015 El Niño. These fires taught stakeholders some valuable lessons about peatland fragility and its socioeconomic drivers. This growing perception about risks on degraded peatlands influenced efforts to scale up restoration activities during the following period.

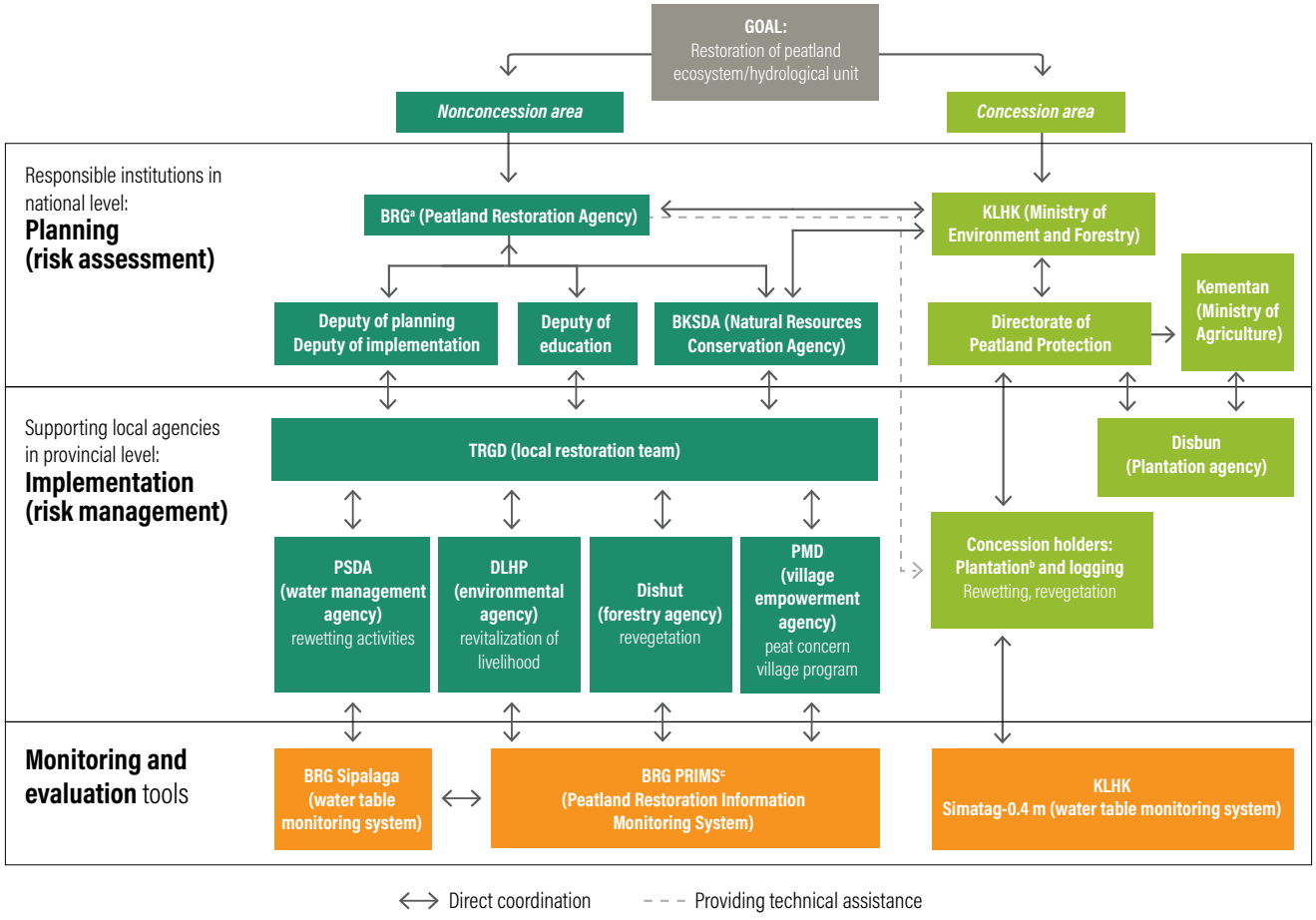
4.2. The Adaptation of Risk Governance in Peatland Restoration, 2016–2019

In 2016, Government Regulation No. 71/2014 was amended by Government Regulation No. 57/2016. Significant changes included the addition of policy measures for evaluating and auditing peatland-use permits and monitoring the 0.4 m water table standard[23] as part of an early warning system.

Government Regulation No. 57/2016 supported the establishment of the BRG, with a mandate to restore 2.6 million ha of peatland in seven priority provinces in Indonesia. This area included 656,884 ha in South Sumatra, mostly in active concession areas (BRG 2019a). This policy scaled up earlier peatland restoration projects and was followed by the creation of the TRGD by South Sumatra's governor.

Figure 8 shows the institutional arrangement of peatland restoration, involving multiple national and local institutions and allocating more financial and human resources to govern peatland restoration. In restoring nonconcession areas, the BRG must coordinate with the TRGD, which facilitates cross-sectoral coordination with multiple provincial agencies responsible for implementing restoration activities. The KLHK is responsible for facilitating restoration in logging concessions and oil palm concessions, coordinating with the Ministry of Agriculture (Kementan) and its provincial agency. Both the BRG and the KLHK need to coordinate their activities before conducting PHU-based restoration.

Figure 8 | **The Institutional Arrangement Governing Peatland Restoration in South Sumatra**



Notes:

[a] BRG had a budget of US$20 million per year for facilitating restoration activities. BRG provides technical assistance about restoration to concession holders.

[b] Business permits for oil palm plantations are issued by the Ministry of Agriculture. To facilitate and supervise restoration in oil palm concessions, the KLHK must have further coordination with the Ministry of Agriculture.

[c] An online platform based on spatial data that provides up-to-date information on the progress of peatland restoration efforts, supported by WRI Indonesia.

Source: WRI Indonesia authors.

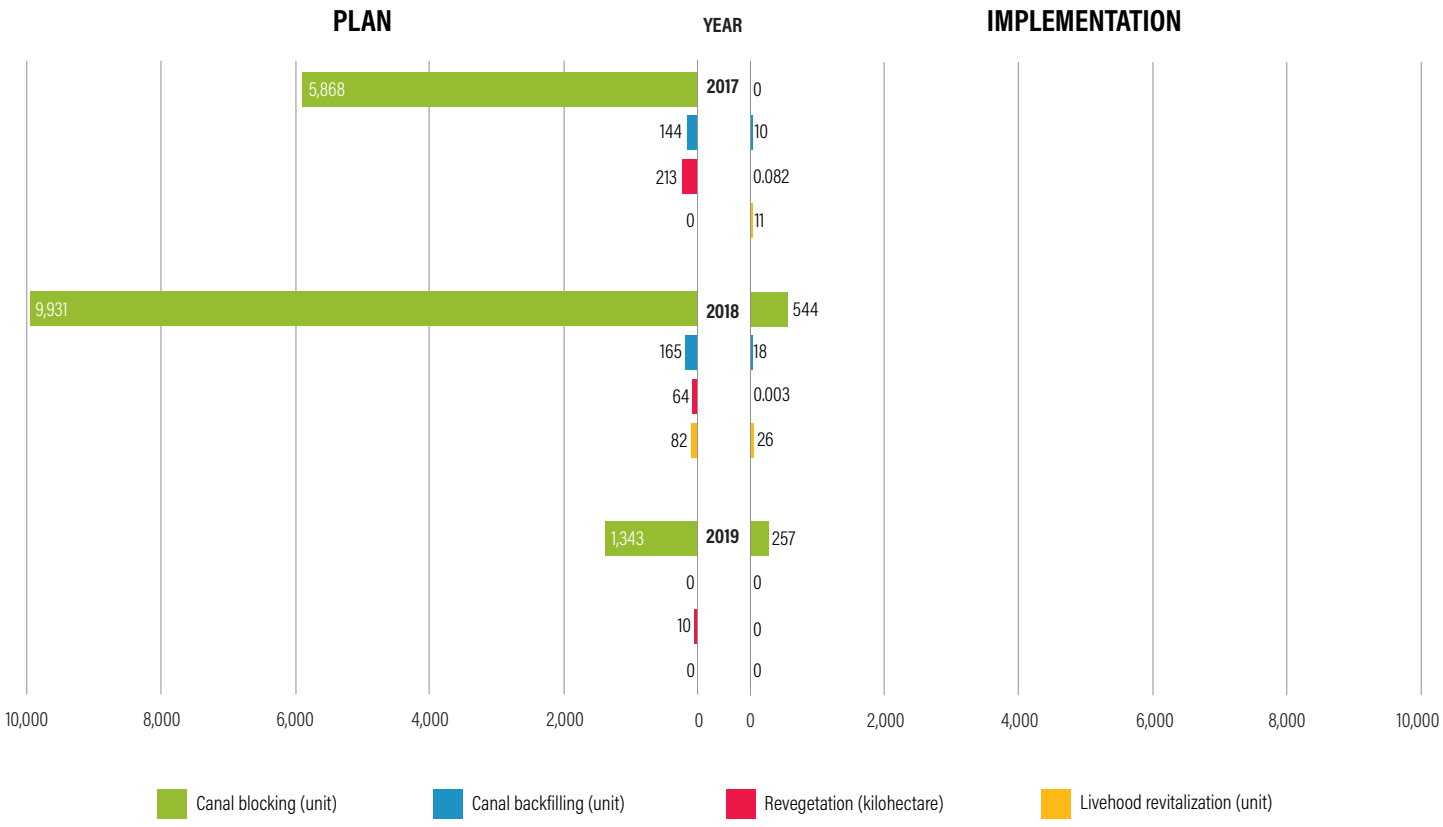
The following sections explain some dynamics in the institutional arrangements that affected the planning, implementation, and monitoring and evaluation of peatland restoration.

4.2.1. 2017: Risk Assessment

The new institutional arrangements began in 2017 with a highly centralized approach to planning and budgeting. That year, the BRG finished the Contingency Plan for Peatland Restoration in South Sumatra. This plan is considered a risk assessment of degraded peatlands. The contingency plan is based on a remote sensing analysis, without ground truthing (BRG 2017). For 2017, it proposed 6,012 rewetting activities and revegetation of 213,352 ha in nine PHUs in three regencies (BRG 2019b).[24]

The TRGD was directed by the BRG to implement this plan. In response, the TRGD presented alternative data and analysis from its local networks—which included local universities and NGOs—that suggested a different plan for restoration. The TRGD accordingly rejected the BRG's plan and proposed the implementation of livelihood revitalization. This situation forced the BRG to approve the alternative plan and implement 11 livelihood revitalization activities in the three regencies. Having been unsuccessful in persuading the TRGD to adopt its plan, the BRG then worked with the Natural Resources Conservation Agency (BKSDA) to conduct 10 rewetting activities. This implementation was far below the initial annual restoration target (Figure 9; see Appendix E for more detailed data).[25] This scaling back was caused by a failure in risk communication between the two institutions and is considered a political vulnerability.

Figure 9 | **The Gap between Planning and Implementing Restoration in South Sumatra, 2017–2019**



Source: KLHK 2019b; BRG 2020b.

Findings from interviews and the abovementioned case in the institutional arrangement imply four possible factors that likely played a role in underachieving the restoration goals in 2017:

- Unreliable or conflicting peat data. Uncertainty prevented the BRG and the TRGD from translating restoration plans into collective action.
- An overly centralized approach by the GoI (through the BRG and the KLHK) influenced the effectiveness of coordination between the national and the provincial institutions. The TRGD's preference for its own data, and its rejection of the BRG plan, was possibly influenced by the TRGD's expectation that the BRG would share authority when planning and budgeting for restoration.
- The absence of a provincial regulation on peatland restoration reduced (political) power to push restoration implementation.
- The TRGD and the BRG favored different strategies for implementing restoration.[26] The TRGD indicated that it wanted to begin with livelihood revitalization because it included economic incentives[27] that might encourage local communities to be more accepting of subsequent rewetting and revegetation activities. The BRG preferred the conceptual approach of beginning restoration with rewetting and revegetation.

These different approaches are an example of the difficulty in reaching a collective decision about risk management for peatland. This is especially difficult for a country such as Indonesia, where the newly emerging institutions of the BRG and the TRGD are learning while attempting to do their jobs.

4.2.2. 2018: Risk Handling

For 2018, the BRG proposed 10,096 rewetting activities, a revegetation of 64,000 ha, and 82 units of livelihood supports in South Sumatra (see Figure 11). The experience[28] gained in 2017 led the BRG to make two changes in its governance strategy for restoration in 2018. First, the BRG revised the financial scheme within the institutional arrangement by dividing its budget allocation into two streams: direct appointment and coadministered tasks. The BRG directly appoints the BKSDA[29] in South Sumatra, and coadministration tasks are carried out by a provincial environmental agency, the Department of Environment and Land (Dinas Lingkungan Hidup dan Pertanahan; DLHP). The DLHP is part of the TRGD team. The BRG and the DLHP jointly carry out restoration tasks with other local agencies (Figure 10). Since the DLHP is part of the TRGD, this strategy is supposed to overcome the previous issue between the BRG and the TRGD. However, a communication issue between the TRGD and the DLHP caused the implementation of restoration activities to disintegrate. Second, the BRG modified the risk assessment strategy by involving the TRGD in restoration planning;[30] this improved the contingency plan and decentralized the planning approach. To verify the contingency plan made by the BRG's deputy of planning, the deputy of implementation conducted a rapid assessment[31] with the TRGD before implementing restoration. The rapid assessment was supposed to validate peat data in the contingency plan through specific ground checking. Unfortunately, the rapid assessment was carried out from a helicopter, without ground checking to measure bulk density and verify the actual existence of peat. This mistake led to restoration not being implemented in areas that still had peat, which reduced the effectiveness of implementation in 2018. There is an indication that this mistake occurred due to a lack of detailed technical guidelines for rapid assessment and the absence of expert involvement.

At the provincial level, local governments also learned from the mistakes of 2017 and took corrective action by issuing new policy instruments: Provincial Regulation No. 1/2018 on peatland protection and Gubernatorial Regulation No. 68/2018 on an institutional arrangement for peatland protection. These regulations became the legal support for restoration projects implemented by local governments in South Sumatra. They also encouraged local governments to establish a network with NGOs to coordinate restoration efforts (Global Planet 2018). These improvements from the BRG and the provincial government contributed to the increasing implementation rate of restoration.

However, a new element of political vulnerability emerged. The failure of negotiation and communication between the BRG with the TRGD in 2017 led to a change of communication strategy by the BRG's deputy of implementation. The deputy chose to coordinate more with a specific institution, such as the DLHP,[32] rather than the TRGD. The deputy of education, who was responsible for peat care programs, followed suit.[33] In 2018, the provincial facilitator under the deputy of education reported directly to the deputy without communicating with the TRGD. These new working arrangements altered the networking structure of the initial institutional arrangement for peatland restoration in South Sumatra (Figure 10). The change might have been influenced by the fact that the head of the BRG and the governor of South Sumatra did not compel their subordinates to follow the original institutional arrangement. The change later contributed to greater fragmentation in implementing restoration activities. This shows the importance of risk communication. Some examples of how the implementation of restoration activities can fall short of planning are provided in Box 1.

Meanwhile, the KLHK was preparing technical regulations to support the implementation of PP 57/2016. The ministry made a separate arrangement to facilitate restoration by concession holders. Several procedures are necessary for concession holders to conduct an official restoration:

- Concession holders must receive a letter from the KLHK requesting them to create a restoration plan that is integrated with the five-year company business plan
- The restoration plan is reviewed by the KLHK
- If the plan is approved, the concession holder receives another letter to implement the restoration

Since 2018, the KLHK has requested restoration plans from 20 concession holders in South Sumatra. As of the end of 2018, no restoration plans had been approved,[34] yet some concession holders were moving ahead with restoration.

Box 1 | Restoration in Four Peatland Hydrological Units in South Sumatra

The peatland hydrological units (PHUs) of Saleh-Sugihan, Sugihan-Lumpur, Lalan-Merang Ngirawan,[a] and Burnai-Sibumbung were restoration priorities in 2017 and 2018. Our field observations and measurements in these PHUs revealed that restoration implementation increased in the area, but there were various issues with it.

Village-level issues

- A lack of ground truthing before implementation meant that restoration activities were carried out in villages where no peat existed.[b] The Government of Indonesia did not update peatland data after the 2015 fires[c] and used old peat data[d] for the contingency plan that was implemented in 2018. It seems likely that the absence of peat in both PHUs was due to recurrent fires. This is an example of political vulnerability in the planning phase of restoration and risk assessment.
- In four villages in PHU Sugihan-Lumpur, livelihood revitalization activities and Peat Care Village programs (Desa Peduli Gambut; DPG) had been done and included livelihood support for the community. Yet no other restoration activities, such as rewetting, were carried out in the villages.[e] Livelihood revitalization and DPGs alone are not enough to reduce fire risk, and in September–October 2019, those villages suffered from fires on 14,113 hectares (ha) of peatland.

Concession issues

- Concession holders argued that the bureaucratic process of the Ministry of Environment and Forestry (Kementerian Lingkungan Hidup dan Kehutanan; KLHK) was too long—taking up to three years—and delayed the implementation of restoration activities in concession areas.
- By October 2019, two companies in PHU Burnai Sibumbung had been contacted by the Peatland Restoration Agency (Badan Restorasi Gambut; BRG) to assist with their restoration planning and activities. Yet there was no substantive integration between the BRG's role in providing technical assistance[f] for restoration and the KLHK's authority to approve concession holders' restoration plans.

In general, although restoration activities had been implemented in villages and concession areas, they were not well coordinated within the PHUs and were not well connected to earlier restoration projects.[g] This fragmentation results from the failure of implementing agencies to coordinate their planning and implementation of restoration activities. For example, across BRG programs, fragmentation led to inefficiencies in livelihood revitalization and DPGs, both of which aim to reduce anthropogenic pressures on peatland. DPGs and livelihood revitalization in PHU Burnai-Sibumbung (where peat existed[h]) were implemented in seven and four villages, respectively. In three villages, both programs were found to have duplicate activities. Both provided livelihood support[i] to the community without coordination[j] or integration at the planning or implementation stage. In addition, the livelihood aid was delivered through the heads of the villages, who often selected their peer group as the beneficiaries. The peer group usually did not involve individuals who relied on peat for their living;[k] thus, the aid did nothing to relieve pressure on peatlands.

Concession holders have also pursued uncoordinated restoration activities.[l] We found that two oil palm plantation companies (Gading Cempaka Graha [GCG] and Rambang) in PHU Burnai-Sibumbung have undertaken restoration activities as a local preventive measure after the devastating fires in 2015–16, outside of KLHK procedures. GCG implemented canal blocking and revegetation to help the risk management system in the concession area. GCG claimed that it achieved the 0.4 m water table standard monitored by the government every six months. GCG also found that meeting the standard had not thus far impacted the productivity of the oil palms. Rambang also constructed canal blocks with similar results.

However, canal blocks by Rambang and GCG are limited to their concession areas, and the companies did not coordinate the positioning of their canal blocks with other companies to create an integrated water management system. Nor did the concession holders coordinate with the BRG's canal blocking activity, so water management within the PHU was not integrated; thus, the PHU was not fully rewetted. Overall, though, the water table was reduced,[m] which led to subsidence. The Palembang Environment and Forestry Research and Development Center (Balai Litbang Lingkungan Hidup dan Kehutanan Palembang; Balitbang LHKP) found a subsidence rate of about two to five centimeters in the PHU.[n]

Overall, there is no integration between restoration in villages and concession areas.[o] This might be caused by the existing institutional arrangement, which divides restoration responsibilities between concession and nonconcession areas, in a different organization, and without a proper coordination mechanism. This lack of coordination between stakeholders will eventually derail the establishment of a landscape/PHU approach. During the 2019 El Niño, 3,504 ha of peatland (8 percent of the area targeted for restoration[p]) were burned in PHU Burnai-Sibumbung; 1,713 ha in concession areas; and 1,790 ha in the nonconcession area. It suggests that the quantity and quality of restoration activities in PHU Burnai-Sibumbung had yet to reduce peat vulnerability to fires. Appendix J shows the governance of peatland restoration in the PHUs observed.

Box 1 | Restoration in Four Peatland Hydrological Units in South Sumatra (Cont'd)

FIGURE B1.1 | FIRES IN PHU BURNAI-SIBUMBUNG, 2019

Source: Ismi 2019.
Notes:
[a] Field observations and measurements in PHU Lalan-Merang Ngirawan were canceled due to COVID-19.
[b] Based on the results of our bulk density measurement in two villages in PHU Saleh-Sugihan and in the wildlife reserve in PHU Sugihan-Lumpur.
[c] Gatra.com 2019.
[d] In addition, it is possible that the original maps have been less accurate in delineating peatland extent.
[e] The Peatland Restoration Agency mentioned that the DPG should be initiated in the area where rewetting, revegetation, and livelihood revitalization had been or would be conducted. But this did not happen in the observed villages.
[f] Such as checking peat maps, offering guidance on integrated water management systems, and canal blocking and backfilling. This technical assistance is an incentive for companies with good intentions to restore peatlands. In 2020, the BRG had provided technical assistance for concession holders conducting restoration. The assistance was provided to eight oil palm concession areas covering more than 78,000 ha. Another 423,065 ha of concession areas for industrial forestry were not being assisted as of the end of 2019. This is due to the lack of coordination between the BRG and the KLHK *(Kompas 2020)* and the lack of capacity in the agencies to provide the technical support across the whole of the areas targeted for restoration.
[g] The restoration project by the Balitbang LHKP in 2010 in the Kayuagung village that lays within PHU Burnai-Sibumbung.
h Our bulk density measurement proved the existence of peat in the area.
[i] The BRG argues that the DPG should generate the livelihood revitalization through economic improvement and other activities, but this is not found in the observed villages. Some DPGs are run by NGOs.
[j] There was a lack of coordination between the NGOs (who run the DPGs), the deputy of implementation's team (in charge for livelihood revitalization), and the deputy of education's team (in charge of the DPGs).
[k] Such as *purun* farmers. Some activities of *purun* collection, such as spending nights on peatland (which involves igniting fires or smoking), could potentially trigger fires, especially in the dry season.
[l] This restoration was a local initiative, not the one requested by the KLHK. The activity was supported by police and the army, which are often used by concession holders to support fire mitigation efforts, including restoration. In 2019, Gading Cempaka Graha and Rambang had not yet received the letter to begin restoration from the KLHK. In 2020, GCG derived technical assistance from the BRG.
[m] Westhoff 2020.
[n] Bastoni 2019.
[o] The lack of integration is influenced by a lack of incentives to do it.
[p] The area targeted for restoration in villages observed in this study.

By the end of 2018, South Sumatra had achieved less than 10 percent of its annual restoration target in nonconcession areas.[35] Figure 11 shows that it mostly came from rewetting[36] activities, which are an important part of restoration (BRG 2020b). Some barriers related to institutional capacity, inconsistent peat data, an absence of detailed planning, and a lack of community acceptance. In some villages, communities rejected the construction of canal blocking because it triggered flooding during the wet season and/or blocked boat access. The quality of implementation across nine PHUs in the province reflects many of the difficulties described in Box 1.

In concession areas, the KLHK was still forcing the concession holders to conduct 2,959 rewetting activities (DLHP 2019; KLHK 2019b). We could not access information about which concession holders will implement the actions.

The landscape approach has not been widely adopted in peatland restoration in South Sumatra. BRG and KLHK data are not integrated, so there is no joint target or joint planning and implementation program for PHUs in the province. The BRG has no authority[37] to collect data from the KLHK, which lacks transparency, and both institutions lack substantial coordination. The institutional capacity of the responsible organizations is weak regarding the landscape approach. The implementation of restoration activities is still output oriented (measured mainly by the money invested) rather than focused on the results of the investment (Kartodihardjo et al. 2018). Likewise, stakeholders' understanding of the landscape/PHU-based restoration concept is still limited. At the national level, technical regulations are still being developed (Wijaya 2019b).

In late 2018, the BRG, with the support of an NGO consortium, created a detailed Annual Action Plan (Rencana Tindak Tahunan; RTT) for 14 PHUs in South Sumatra (see Box 2). Improvements included ground truthing and participation by local stakeholders to verify the plan. The ground truthing exercise found that about 60 percent of peatlands do not match the locations recorded in earlier government peatland data (KPRGSS 2018). Four PHUs had completed the RTT by the end of 2018; the RTT focused on the areas that still had intact peat and matched BRG data. The RTT also was used for restoration planning for some PHUs in 2019. This progress is considered an improvement in risk assessment and evaluation in the governance of peatland restoration.

Box 2 | A Detailed Restoration Plan for 14 Peatland Hydrological Units in South Sumatra

The South Sumatra Peatland Restoration Planning Consortium (Konsorsium Perencanaan Restorasi Gambut Sumatra Selatan; KPRGSS), which comprises World Resources Institute Indonesia, World Agroforestry (ICRAF), and Wetlands International Indonesia, has completed South Sumatra's 2018–23 Peatland Ecosystem Restoration Plan (Rencana Restorasi Ekosistem Gambut; RREG) and the 2019 Annual Action Plan (Rencana Tindak Tahunan; RTT) for peat restoration in 14 peatland hydrological units in South Sumatra. The two planning documents serve as key references for peat restoration activities at the local level.

The RTT follows the principles of risk assessment and evaluation in the risk governance concept. The KPRGSS, in partnership with the Provincial Peatland Restoration Agency, provincial agencies, concession holders, and communities, conducted a risk assessment in the target restoration area that was based on science and tailored to actual situations in the field. The risk assessment was then evaluated by local stakeholders to ensure validation of the restoration plan. This cocreation approach makes a contextual site-specific restoration plan that will be used for restoration implementation from 2019 onward.

In 2018, the BRG also began developing the Peatland Restoration Information Monitoring System (PRIMS) as a systematic monitoring and evaluation (M&E) tool. To support PRIMS, the BRG and the TRGD conducted randomized M&E for some rewetting activities. However, there is no formal report or section about the M&E[38] in the BRG's 2019 implementation report.

The abovementioned findings show that there have been some improvements in peatland governance since 2017:

- A more decentralized approach was used for the institutional arrangement; the BRG involved the TRGD and provincial agencies in managing planning and budgeting for restoration.
- Agreement was reached between the BRG and the TRGD to use one peat data set and the same restoration approach for translating detailed restoration plans into action.
- Provincial Regulation No. 1/2018 on peatland protection was issued, as was Gubernatorial Regulation No. 68/2018 on its institutional arrangement.

However, there are still some political vulnerabilities that need to be addressed:

- The absence of a precise restoration plan hampered some implementations.[39] This contributed to underachievement of the 2018 restoration goals.
- Communication issues among institutions fragmented the implementation of restoration activities in villages and concession areas, and the PHU approach was not initiated.

These issues are connected to the material vulnerabilities produced during the following year.

4.2.3. 2019: Material Vulnerabilities amid Improvements

In January 2019, the TRGD and its members (local government agencies) held a meeting to coordinate restoration activities. However, the TRGD's efforts failed due to intense personnel conflicts among officers in the institutions, which had originated with the 2018 communication issue. TRGD personnel had been appointed by the previous governor, whose tenure ended in 2018. Following a regime change in the provincial government, South Sumatra's new governor later changed personnel on the TRGD team.[40] This bureaucracy change caused a delay in implementing the province's restoration activities planned for 2019.

In February 2019, the BRG officially introduced PRIMS as a national platform for M&E of restoration (see Appendix M). PRIMS is an online platform based on spatial data that provides up-to-date information on the progress of peatland restoration efforts and their impact.

In August 2019, the president of Indonesia issued Presidential Instruction No. 5 of 2019 concerning the Cessation of Granting of New Permits on Peatlands as an improvement on Presidential Instruction No. 6 of 2017 concerning the Moratorium of Granting of New Permits on Peatlands. This new regulation permanently stops the granting of new licenses to convert peatlands.

Unfortunately, these new policies[41] and governance improvements faced the peak of El Niño during the following month. Political vulnerabilities in restoration governance in 2017–18 and El Niño contributed to material vulnerabilities in the form of peat fires, carbon emissions, economic loss, and respiratory illnesses in 2019.

In early September 2019, more than 80 percent of groundwater table stations in South Sumatra recorded water table levels more than 0.9 m below the surface, far below the government standard of 0.4 m (BRG 2019c). This implies that 8 out of 10 restoration areas with groundwater stations[42] are still vulnerable to fires.[43] By the end of 2019, between 139,084 and 174,341 ha of peatland had burned in South Sumatra; about 2 percent of that area fell within restored areas, such as in Muara Medak and Cengal (KLHK 2020; UMD n.d.). Some of the canal blockings were burned (Ismi 2019). Fifty-one percent of the area that burned in 2019 is located in (new) concession areas where the progress of restoration is slow.

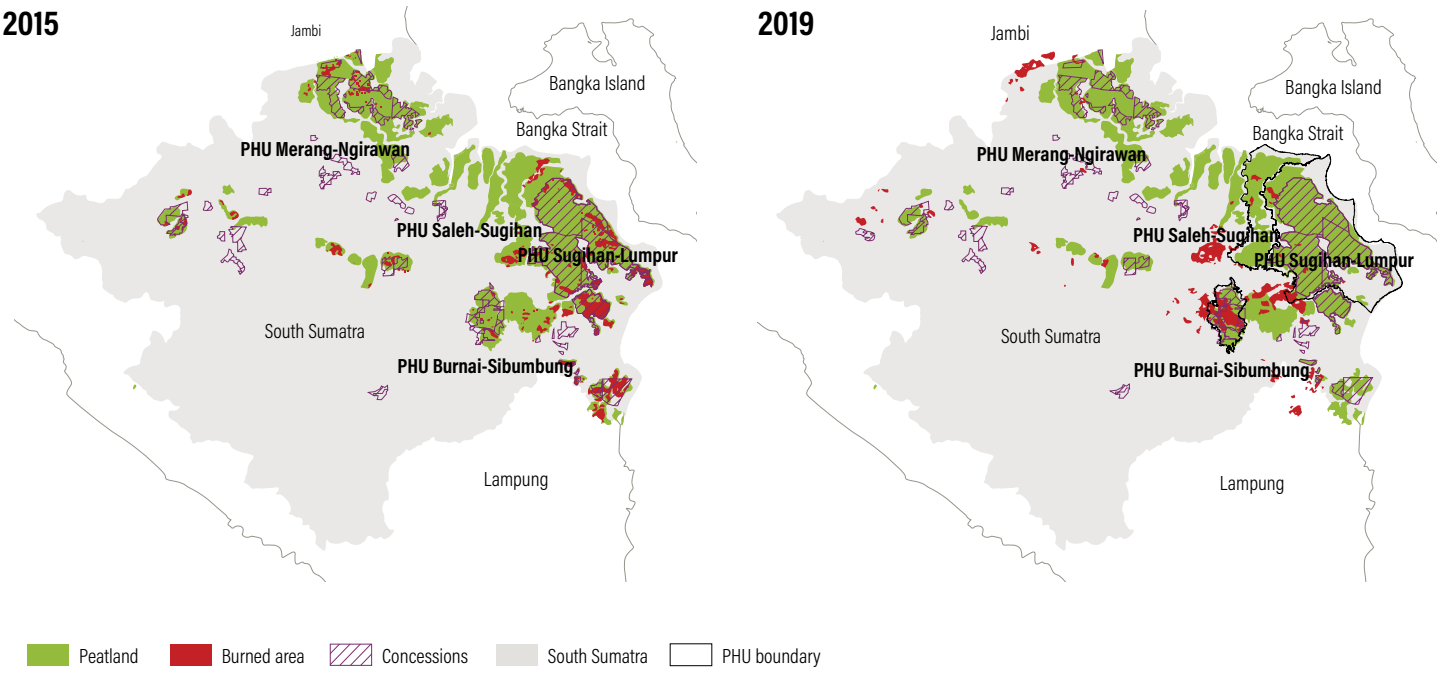
The 2019 peat fires in South Sumatra were worse than those of 2015 (Figure 10). Peatland areas that had not burned in 2015–18 made up around 70 percent of the total area burned in 2019 (Dishut Sumsel 2020). Seventy-six percent of these newly burned peatlands were found in concession areas. Some of the drivers of the new fires include slow restoration progress on concession areas[44] and new land conversion (78,607 ha per year[45]) to oil palm plantations in 2015–18. Weak enforcement of the conversion moratorium also contributed to new peatland conversion.

Of the burned peatland areas, 30 percent are located in areas that also burned in 2015–18 (see Appendix H). Slow restoration progress and low implementation quality in some areas contributed to these fires.

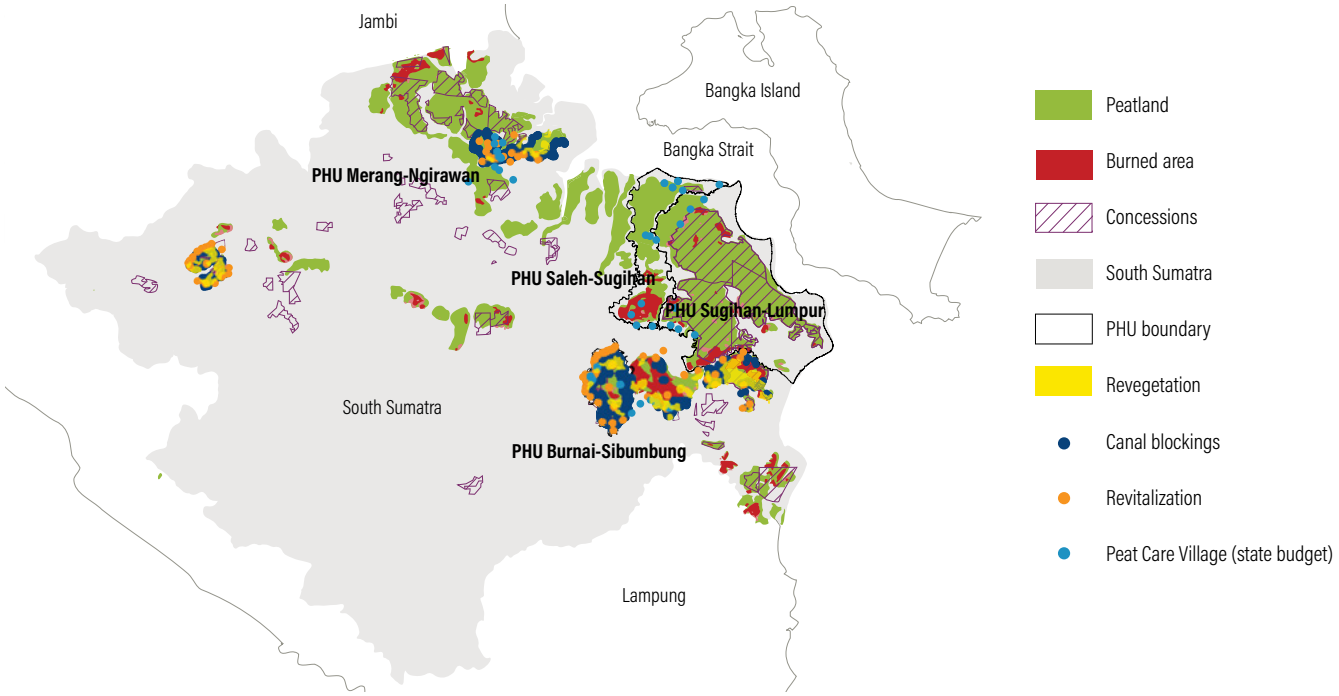
Figure 10 | **Fires in South Sumatra Peatlands in 2015 and 2019**

a. 2015

b. 2019



c. 2019, with Restoration Activities



Notes: PHU = peatland hydrological unit.
Source: WRI Indonesia authors.

The fire hazard disrupted the implementation of restoration activities in 2019, causing fewer activities to be performed that year. BRG records show that 257 canal blockings were installed in 2019, less than 50 percent of the 2018 number. However, the quality improved as the BRG installed a new canal-blocking technology that was equipped with spillways to avoid flooding surrounding villages. This is expected to increase community acceptance of canal blocking.

Meanwhile, KLHK records show that some concession holders had carried out restoration activities and followed water tables requirements (KLHK 2019a; *Kompas* 2020); however, as of 2019, no official restoration plans for concession holders had been approved.[46] As of the end of April 2020, the KLHK's official 2019 implementation report was still not available.

4.2.4. Restoration as Risk Governance on Peatland Management in 2016–2019

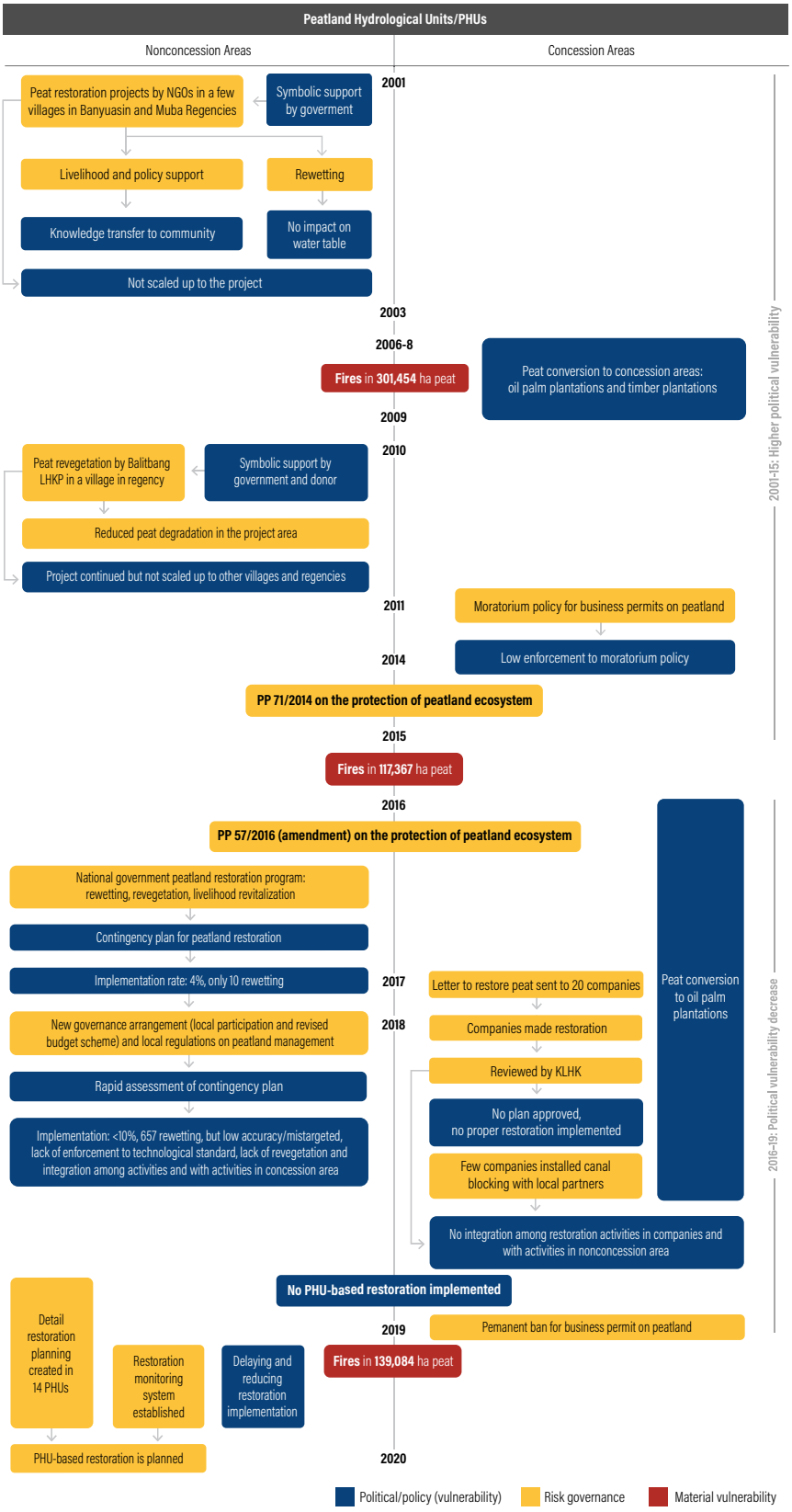
The period 2016–19 shows an improvement from the previous period of peatland management (see Figure 11 and Appendix G). Appendix K shows a list of the adaptations and adoptions of risk governance principles in the governance of peatland management in 2016–19. It includes the following points:

- A better understanding of sustainable peatland management led to serious political support from the national and provincial government in the form of regulations and funding to scale up restoration projects.
- Adaptive learning increased across restoration actors due to more coordination across implementing agencies (national and provincial governments, NGOs, concession holders).
- The national government's 2019 policy of permanently stopping the granting of permits for oil palm and industrial forest plantations on peatland can increase restoration effectiveness.
- A detailed RTT was completed for 14 PHUs as a proper risk assessment.
- PRIMS was established.

However, even these restoration activities and improvements were not enough to prevent the devastating fires of 2019 (Figure 11). Between 2015 and 2019, a total of 304,235 ha of peatland were burned in the province (UMD n.d.; YMB 2020).

We argue that the centralized governance of peatland restoration activities at the national and provincial levels, with the division of concession and nonconcession areas, continued to drive political vulnerability. This made it difficult to conduct PHU-based restoration. The implementation of restoration activities was still based on the site/project level, not integrated within the PHU. Efforts to rewet peat and introduce alternative livelihoods were still fragmented. These efforts were not enough to restore peat and address the socioeconomic drivers of human pressures on peatlands. In addition, they did not build the capacity of local communities to continue restoration efforts, so they still may need to rely on project assistance.

Figure 11 | The Adaptation of Risk Governance Principles in Peatland Restoration in South Sumatra



Source: WRI Indonesia authors.

5. CONCLUSION

After the 1997 fires, stakeholders (particularly policymakers and NGOs) gradually gained a greater understanding of the material vulnerability of peatlands. This resulted in the implementation of some peatland restoration activities in 2001 and 2010 and the issuance of peatland protection regulations in 2014. In 2016, some new risk governance principles started to be adopted under governmental peatland restoration programs, such as detailed risk assessment, risk evaluation, risk handling, and M&E. This has reduced the degree of vulnerability in the policy and governance of risk management on peatlands. Institutional arrangements for restoration have changed from project-based management during the 2000s to national- and provincial-based management after 2016. As a result, more resources and political will are available for peatland restoration. However, landscape-based restorations, which require intensive coordination within a collective institutional arrangement, are not yet a feature of governance strategy.

Meanwhile, the moratorium policy has not stopped peatland from being converted to plantation concessions, which continued through 2015–18. Although the rate of conversion[47] reduced significantly by about 90 percent compared to the period of 2000, its extent was still greater than the restoration activities in concession areas. Thus, the conversion reduced the effectiveness of restoration in resisting fire spread during El Niño years.

The absence of landscape-based restoration and continued peatland conversion to plantations contribute to the inability of peatland management policies and governance to reduce the risk of extensive fires in South Sumatra. The extent of burned peatlands is estimated to have increased from the average of 117,367–144,410 ha in 2015 to 139,084–174,341 ha in 2019,[48] and about 30 percent is located in areas that also burned in 2015–18. These burned areas included some areas where restoration activities were planned and/or implemented.

In 2020, South Sumatra was one of the top five provinces in Indonesia in terms of the most vulnerable peatlands. Figure 12 shows the historical progress as well as the improvements needed in policy instruments and governance strategies to reduce the fire risk on peatlands in the province.

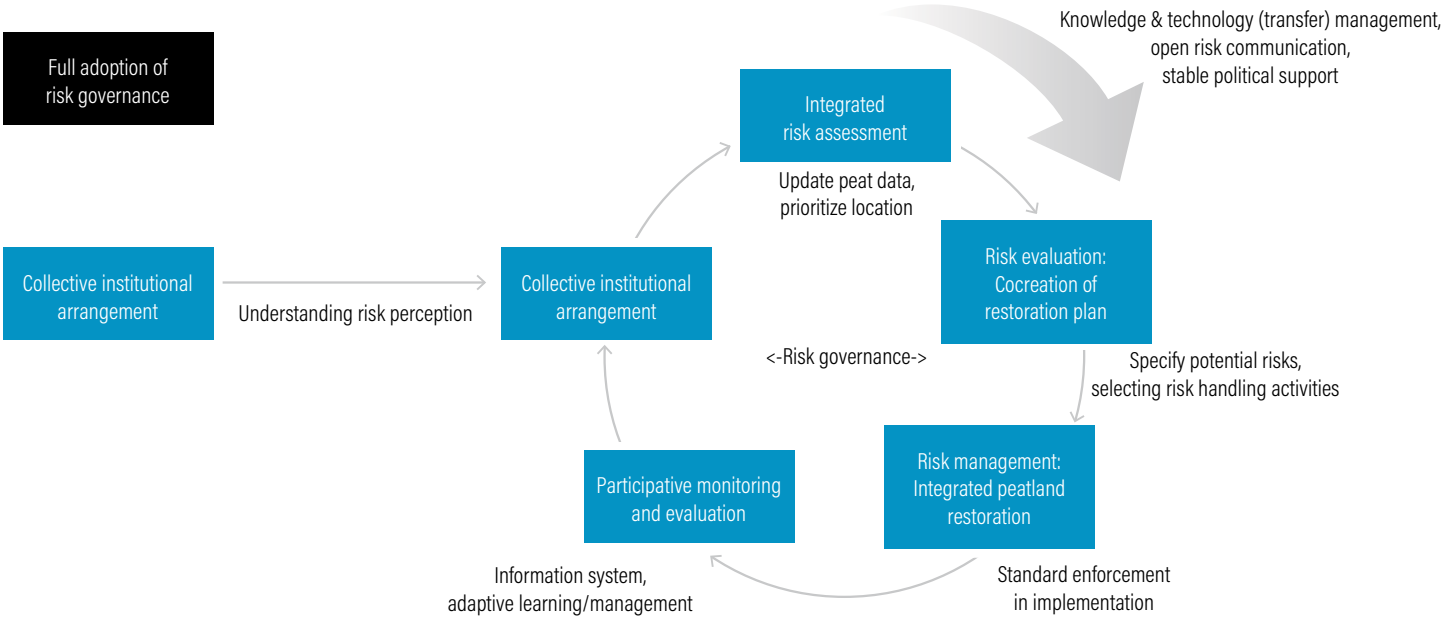
Figure 12 | **The Transition to Sustainable Peatland Management in South Sumatra**

Source: WRI Indonesia authors.

6. RECOMMENDATIONS

The findings of this study provide lessons learned from the governance of tropical peatland management. Corrective action such as restoration is necessary for Indonesia to continue improvements in the governance of peatland management. Besides ensuring consistency in regulations and strong policy enforcement, the detailed adoption of risk governance principles is also required to improve risk management on peatland and serve as a transition to sustainable peatland management (Figure 13).

Figure 13 | **Governance of Landscape Restoration in Peatland Ecosystems**



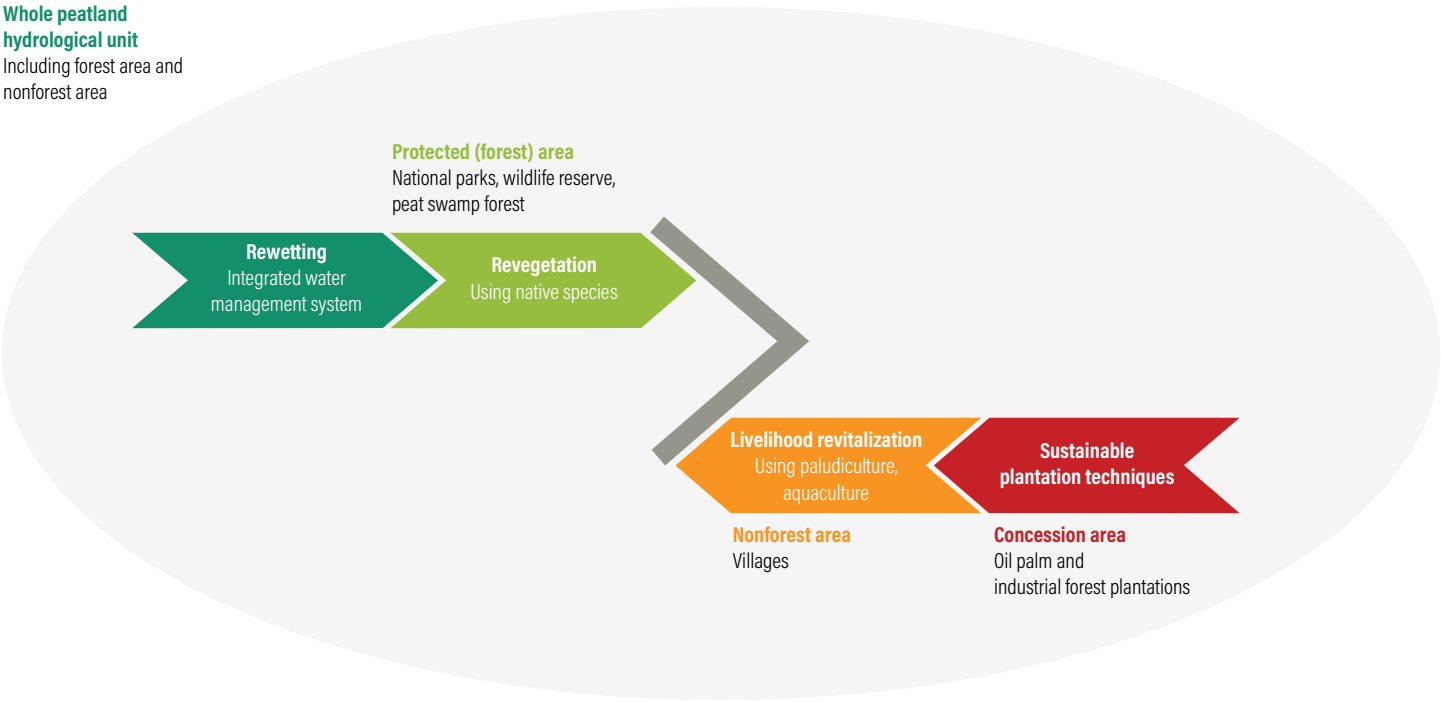
Source: WRI Indonesia authors.

For landscape coordinators such as provincial/regency authorities or concession holders, we recommend the following actions to incorporate risk management principles into peatland governance and stop the cycle of vulnerability:

- Understand the diversity of stakeholders' perceptions of landscape restoration as risk management in peatland.
  - Use participatory approaches to understand the risk perception of (local) stakeholders in a PHU/landscape.
  - Select an engagement strategy to introduce landscape restoration to stakeholders.
  - Identify an internal agent of change or local champion as a partner to approach and engage stakeholders.
  - Make a stakeholders' agreement for collective action in governing peatland restoration.

- Build a governance/institutional arrangement for the peatland landscape.
  - Select an institutional arrangement[49] with more than one lead organization and/or activity center cluster (that can relate to existing and/or previous restoration programs in the area, if they exist).
  - Define and allocate tasks clearly, along with a mechanism for coordination and cooperation among stakeholders in peatland risk management.
  - Connect the landscape-based governance arrangement with regional, provincial, and national government institutions. National and provincial institutions can supervise local institutions, following principles of inclusiveness and equal participation.
    - Integrate tasks and responsibilities, resource allocation, and coordination mechanisms between regional institutions with the landscape-based institutional arrangement.
    - Build institutional capacity in technical and scientific knowledge, project and data management, and effective communication.
    - Involve local research institutions.
    - Shorten the bureaucratic process for restoration in concession areas by having provincial or local environmental agencies issue restoration permits.
- Conduct detailed risk assessment and evaluation.
  - Assign risk assessment tasks clearly to capable organizations.
  - Use an updated database (considering peat loss from the last fire events) in risk assessment.
    - Integrate data across responsible institutions and state and nonstate actors.
    - Use multiple data sources, including spatial, biophysical, and socioeconomic data.
- Conduct risk evaluation and disseminate results publicly; practice open negotiation and effective communication for collective decision-making.
- Create a restoration plan based on the evaluation of the risk assessment.
  - Prepare a plan for integrated risk handling activities/risk management: soil rewetting, revegetation, and livelihood revitalization.
  - Synchronize the plan with the previous or current restoration plan.
  - Consider trade-offs and synergy between restoration activities and other activities across the peatland ecosystem.
- Implement integrated risk management and sustainable peatland management practices (Figure 14).
  - Include soil rewetting with adequate standardized canal blocking and backfilling as part of an integrated water management system.
  - Perform revegetation and develop paludiculture for village livelihoods.
  - Manage anthropogenic pressures.
    - Enforce laws to prohibit new or expanded business permits on peatlands.
    - Revitalize livelihoods of rural communities, in conjunction with the revegetation approach, and transfer knowledge, skills, and technology.
- Use participatory M&E techniques, combining remote sensing and scientific monitoring with community and civil society participation.
  - Involve civil society organizations and community groups to raise community awareness of M&E.
  - Cooperate with local organizations to promote knowledge transfer and capacity building for M&E.
  - Monitor canal blockings, water table levels, soil moisture, vegetation, livelihoods, and fire events.
  - Ensure responsible data management by using an open peatland restoration information system.

Figure 14 | **Integrated Restoration of a Peatland Ecosystem in Different Area Functions within a PHU**



Source: WRI Indonesia authors.

A pilot project that follows all these steps will take about 10 years to implement. In addition to physical characteristics, the local culture, knowledge level, and politics must also be considered carefully when conducting and communicating each step. Urgent action is required to test and operationalize the landscape-based restoration approach to peatland management.

APPENDIX A. CONCEPTUAL FRAMEWORKS

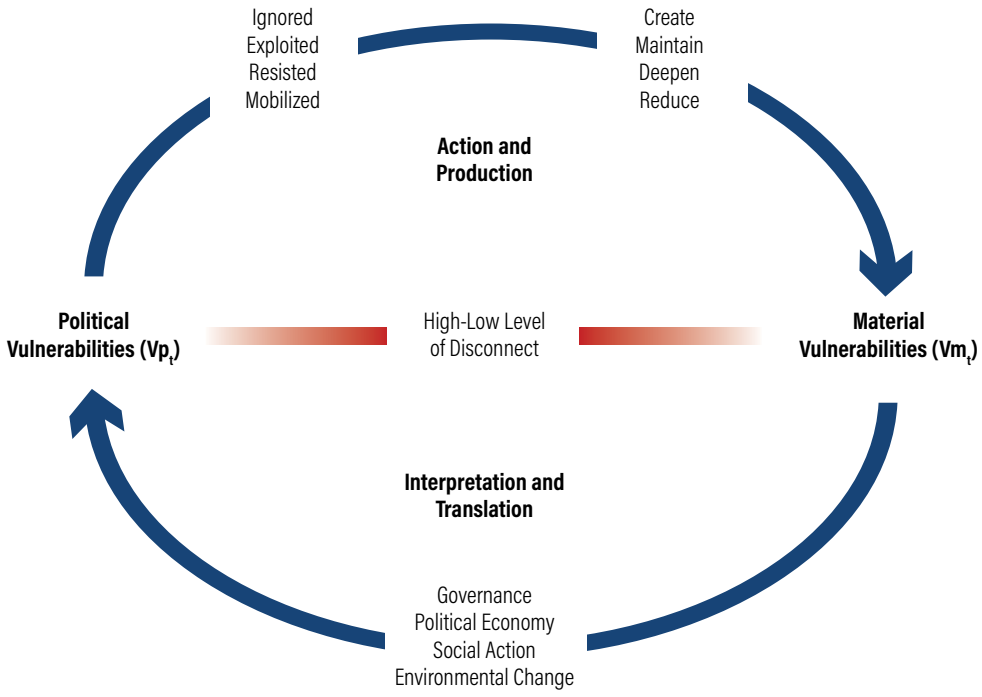
A.1. The Cycle of Political and Material Vulnerability

The vulnerability cycle theory analyzes how a lack of knowledge by policymakers about the science of sustainable peatland management and the absence of ground-truthed information can influence the quality of policies. In the case of peatland restoration, the process becomes more complex because its governance requires intensive coordination between national institutions, provincial bodies, and local stakeholders such as community groups and concession holders. The inability of policymakers and stakeholders to deal with this complexity is called political vulnerability. It often results in poorly judged interventions and leads to unintended consequences such as fires hazard, GHG emissions, and reduced quality of life. These impacts are known as material vulnerabilities. Vulnerabilities are translated from political to material through some actions in the governance process (Simon 2012). In this study, we call it a linking mechanism. The disconnect between policy intention and outcome is often continued over time and creates a cycle of vulnerability.

Peatland governance follows the principle of land use and forest governance where there are mixed roles of government, community, and market actors such as private sectors in managing the area (Agrawal et al. 2008). This peatland governance approach has been difficult to implement in Indonesia. The history of peatland management in Indonesia shows that conflicting policies and the absence of a suitable governance model have contributed to the recurrence of fire events (Budiman et al. forthcoming; Purnomo et al. 2017). This risk might continue in the management of current peatland restoration (Kartodihardjo et al. 2018). To study it, we use the framework of the cycle of vulnerability that analyzes the disconnection between policy and governance with the ground situation (Simon and Dooling 2013).

Vulnerability operates in two forms. The first form is a political vulnerability such as a malfunction of complex governance arrangements, political-economic activity, and civil society actions that respond incorrectly to the ground situation; this creates the second form of vulnerability, which is material vulnerability (Figure A1). It is an empirical situation, such as the fire hazard and its impact (e.g., haze, emissions, and respiratory illnesses) (Simon and Dooling 2013).

Figure A1 | **Vulnerability in the Policy and Governance Cycle**



Source: Simon and Dooling 2013.

The previous study utilized relational inquiry and diverse spatial-historical data to highlight vulnerabilities in the largest urban wildfire in California (in terms of the number of dwellings lost). The study showed that the persistent disconnection between material and political forms of vulnerability has, over time, resulted in contradictory landscapes in which homes are intentionally placed in landscapes vulnerable to wildfires with reduced fire protection (Simon and Dooling 2013). This finding resonates with the case of recurrent peatland wildfire in Indonesia (Barber and Schweithelm 2000).

Peatland restoration is a policy action intended to reduce the fire risk on peatland areas. Peatland restoration faces different dynamics in various geographic regions. For countries in the Northern Hemisphere, such as the United States, governments, regulators, and corporate citizens have recognized since the mid-1990s that cost-effective restoration was critical for degraded peatlands (Chimner et al. 2016). In tropical peatlands such as Indonesia, the call for peatland restoration started in the 2000s, initiated by NGOs and scholars (Budiman et al. forthcoming; van Noordwijk et al. 2014).

Some of the issues involved in promoting peatland restoration include gaining the support of local policymakers, engaging with the local community, and enforcing that businesses conduct peatland restoration (Kartodihardjo et al. 2018). In Indonesia, it took more than 10 years for NGOs and academics to persuade the government to finally issue regulations in 2014 for the protection and sustainable management of the peatland ecosystem (Budiman et al. forthcoming). After the 1997 fires, peatland restoration was fragmented in multiple projects, actors, and designs. In 2016, the GoI formally institutionalized peatland restoration efforts by establishing the BRG and upgraded the Subdirectorate of Peatland Management in the KLHK into the Directorate of Peatland Degradation Control. The BRG and the KLHK were given a mandate for five years (2016–20) to facilitate local stakeholders and concession holders in restoring a 2.6 million ha peatland across seven priority provinces, particularly on already burned peat and protected peat. The responsibilities are divided between the BRG and the KLHK based on the function of the area; the BRG is responsible for restoring nonforest areas, and the KLHK must urge concession holders (industrial forest and oil palm plantations) to restore peatland in their areas. For oil palm concessions, the KLHK must collaborate with the Directorate General of Plantation at the Ministry of Agriculture (Budiman et al. forthcoming). Given the issues during the 2000s, the current complex network of institutional arrangements implies a potential political vulnerability in the governance of peatland restoration (Kartodihardjo et al. 2018).

A.2. Risk Governance to Manage Peatland Restoration

To stop the vulnerability cycle, policymaking needs better data, institutions need reform, and implementation needs more coordination and enforcement (see Figure 2). To deal with the complexity and vulnerability cycle of peatland management, a suitable governance framework is required. This framework must be able to help policymakers and stakeholders cope with multiple uncertainties (technoscientific knowledge, institutional strategy, and politics) in complex socio-environmental actions such as peatland restoration (Renn 2017). The risk governance framework has been used for multiple cases of environmental issues (Hegger et al. 2014; Renn and Schweizer 2009; Renn and Walker 2008; Van Asselt and Renn 2011).

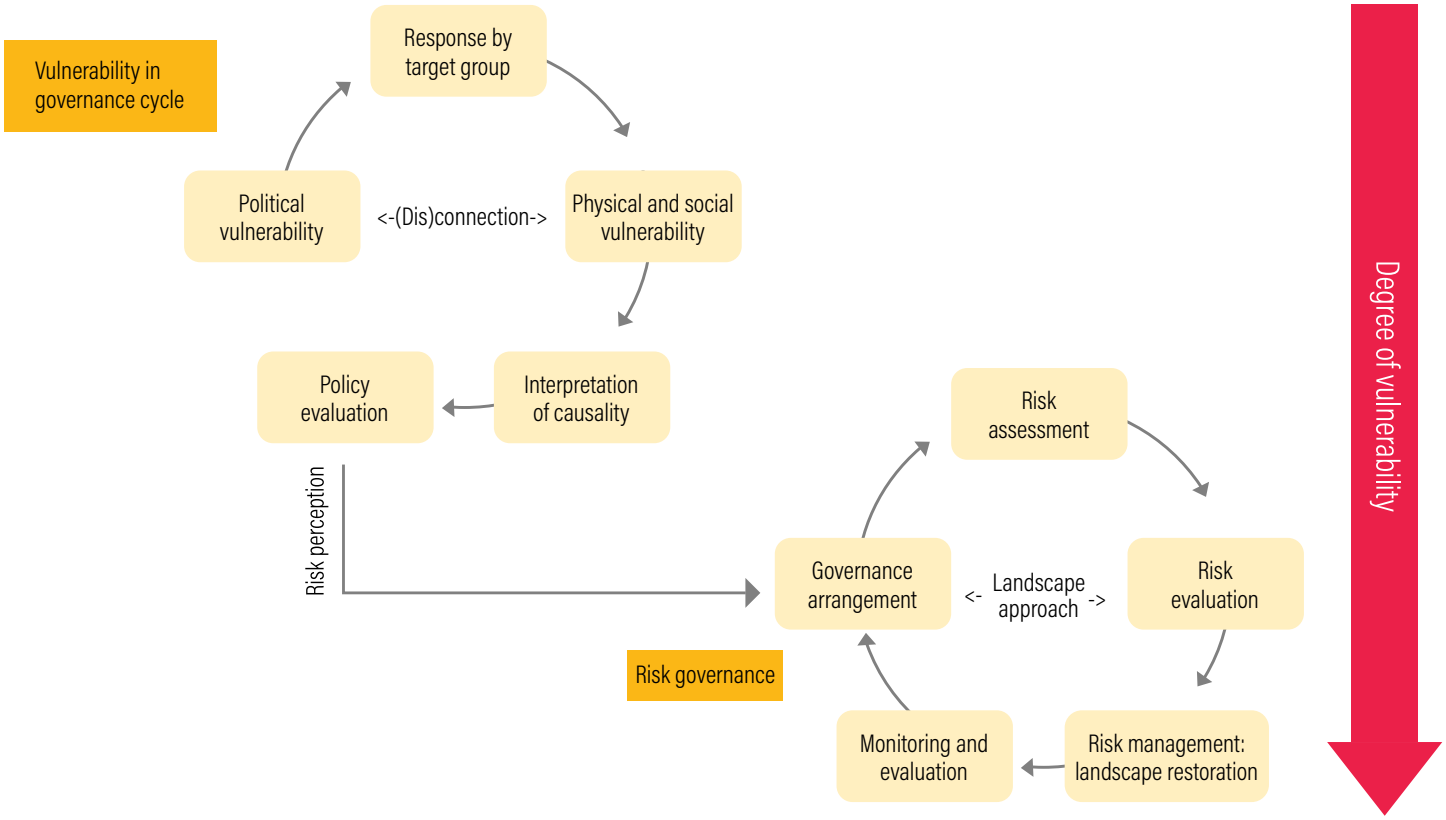
To analyze the case study, a risk governance framework is adapted with these following actions (see Figure 4):

1. Evaluate governance practices that cause the cycle of vulnerability within the management of peatland restoration.
2. Understand stakeholders' perceptions of risk on peatlands.

   Prepare a robust network model of institutional arrangement to govern peatland restoration based on the PHU landscape. The institutional arrangement should have a consensus on resources allocation, division of tasks and responsibilities, and a coordination mechanism among actors (Budiman and Smits 2020; TRANSrisk 2017). Involving multiple actors in the decision-making process can integrate knowledge as well as the variability of values necessary to make effective, efficient, fair, and morally acceptable decisions about risk (Renn and Schweizer 2009).
3. Select actors to conduct risk assessment in the target restoration area.
4. Evaluate the risk assessment findings with local stakeholders. This will help to reduce political vulnerability by creating a contextual site-specific restoration plan to manage risks. This plan must be made in consensus with local stakeholders.
5. Implement integrated peatland restoration with the coordinated setting in the institutional arrangement.
6. Ensure that M&E is inclusive and participative.

Figure A2 shows that these topics are included in the risk governance theory as part of a strategy by the risk manager and/or team to cope with the uncertainties inherent in complex socio-environmental actions such as peatland restoration (Renn 2017). Figure A2 is utilized to analyze findings in this study.

Figure A2 | **Risk Governance to Reduce Peat Vulnerability to Fires**



Note: Each process requires contextual approach for communication, knowledge transfer, cultural sensitivity, and political bargaining.
Source: Adapted from Renn 2018 and Simon and Dooling 2013.

The following subsections describe two examples of important phases in risk governance: restoration implementation as risk management on peatland and risk communication.

A.2.1. Risk Management: Integrated Landscape Restoration of Peatland Ecosystems

According to Government Regulation No. 71/2014 about peatland protection, here are three approaches to peatland restoration: rewetting dried peatlands, revegetation, and livelihood revitalization. Also, the DPG is included by the BRG to help educate the community and mainstream village policy for sustainable peatland management (BRG 2016; Gunawan 2018).

Soil rewetting[50] aims to support biophysical restoration of peatland. After rewetting, revegetation can be done with the paludiculture concept using native species and species adaptive to acidic soils[51] (Hansson and Dargusch 2018). For (severely degraded) peatland near village areas, choosing a combination of species such as in agroforestry and fishery practices can help ensure the community still gains economic benefits from this revegetation (Giesen 2015; Giesen and Sari 2018; Thornton et al. 2018).[52] Conducting revegetation after rewetting activities will help the process of peat formation, thus potentially restoring the tropical peat ecosystem (Jauhiainen et al. 2008a).

Implementing rewetting and revegetation without addressing the socio-environmental relationship and the livelihood needs of local communities will reduce the effectiveness of restoration outcomes (Medrilzam et al. 2014).[53] Livelihood revitalization is part of the efforts to reduce anthropogenic pressures on peatlands. It must be done in parallel with rewetting and revegetation (Budiman et al. 2020b; Giesen and Sari 2018; Page et al. 2009b). The livelihood revitalization can be accomplished in two ways: by finding an alternative livelihood outside the peatland and/or by transforming slash-and-burn agriculture on peatland into paludiculture practices (BRG 2016; Budiman et al. 2020b; Medrilzam et al. 2014). Reducing anthropogenic pressures through livelihood revitalization is important to stabilize peatland land use during biophysical restoration. This relates to the notion of sociocultural restoration to revisit the way communities interact with the environment (Graham 2013). Besides rural livelihood revitalization, a moratorium on new business permits and adjusting the current cultivation/plantation techniques of concession holders are also required to reduce environmental pressures on peatlands (Afriyanti et al. 2019).

All restoration activities within a PHU must be integrated, as suggested by Indonesian regulation. The aim is to achieve productive and sustainable peatland management within a PHU landscape. This concept integrates effective water management, soil amelioration, fertilization, and socioeconomic intervention in a PHU (Nursyamsi et al. 2016). Thus, the three steps of restoration—rewetting, revegetation, and livelihood revitalization—need to be linked or integrated within the PHU to cover all villages, subdistricts, regencies, and different area functions and statuses (Gunawan 2018). This integrated approach can reduce the risk of widespread fires.

Landscape-level peatland restoration combines three steps: rewetting peat soil in a coordinated manner to create an integrated water management system, using the principles of paludiculture for revegetating peatland, and revitalizing the livelihoods of local communities and regulating the practices of commercial concession holders to reduce anthropogenic pressures (Nursyamsi et al. 2016; Sayer et al. 2013). These activities must be integrated within a PHU (Gunawan 2018) that covers several villages and different types of land use (Figure 3). A PHU is where peatland is bounded between two rivers (Rudiyanto et al. 2016). This unit can consist of several peatland ecosystems that have hydrological connectivity.[54] A previous study shows that the early indicators of recovery in restored peatlands start appearing two or three years after the restoration steps were carried out (Budiman et al. 2020a); the integration is explained in Appendix M.

A.2.2. Risk Communication and Adaptive Learning

Six processes in risk governance require effective communication efforts through coordination and cooperation mechanisms within the institutional arrangement. Communication techniques within the risk governance process need to consider uncertainties and diversity in stakeholders' perceptions, knowledge/understanding about peat management, culture, strategy, institutional capacity, and political-economic interests. Choosing a contextual strategy to communicate the risk of degraded peatland is important not only to increase stakeholder awareness about the urgency of peatland restoration but also to accelerate its implementation as risk management on peatland.

This risk governance framework also has spatial and temporal dimensions. Temporally, the degree of adoption and adaptation of risk governance principles in a project life cycle may vary over time. For example, a peatland restoration project may only adopt or adapt two to three phases of risk governance in three years, and some other phases may be still vulnerable, so the cycle of vulnerability may still occur but in less intensity. Full adoption of risk governance principles into the governance cycle may take a long time, depending on factors such as institutional and actor capacity (Ismail et al. 2019). Spatially, adaptive learning within the institutional arrangement in risk governance has the potential to be scaled up to wider areas, across PHUs and beyond, in the long term. The lessons learned from effective risk governance in one area can be utilized in adjacent areas. These persistent processes can help gradually reduce material vulnerability on peatlands.

APPENDIX B. COMPONENTS WITHIN THE FRAMEWORK

Table B1 | **The Types of Linking Mechanisms and Actions in the Governance Cycle Framework and Its Data Collection Method**

ASPECT	CATEGORY	DESCRIPTION/EXAMPLE OF ACTION	DATA COLLECTION METHOD
Political (vulnerability)	(Un)certainty on policy instruments (regulation, etc.)	■ (Vulnerable) bias on regulation ■ Ambiguous standards, lack of (standard) enforcement	Document review, academic literature, interviews, observation
	(Un)certainty of disintegrated (restoration) activities	■ Disintegrated planning and implementation of restoration activities ■ Overlapping activities ■ Patron-client relations on implementation	Document review, academic literature, interviews, observation, spatial analysis from open-source web app
	Institutional arrangement	■ Absence of clear task division ■ Absence of mechanisms for cooperation/ coordination among institutions to implement policy ■ Lack of enforcement for the arrangement	Document review, academic literature, interviews, observation
Reaction to policy	Ignorance	■ Policy/regulation unrecognized or discounted/ disregarded by stakeholders	Document review, academic literature, interviews, observation
	Exploitation/mobilization	■ Vulnerability/policy produced to concentrate benefits for a specific group	Document review, academic literature, interviews, observation
	Acceptance	■ Supportive action	Document review, academic literature, interviews, observation
Production of material vulnerability	Create, maintain, deepen impacts	■ Vulnerability remains or increases (compared to previous period): number of hot spots, number of respiratory illness cases	Document review, academic literature, interviews, (field) observation, spatial analysis from open-source web app
	Reduced impacts	■ Vulnerability declines	Document review, academic literature, interviews, (field) observation, spatial analysis from open-source web app
	Correlation between physical and social vulnerability	■ Social vulnerability is affected by physical vulnerability ■ Physical vulnerability is influenced by social vulnerability	Document review, academic literature, interviews, (field) observation
Reaction to material vulnerability	Evaluating impacts and political vulnerability	■ Gathering evaluation result for improving performance of peatland restoration	Document review, academic literature, interviews, observation
Governance evaluation	Policy instrument, governance model, institutional arrangement	■ Response to the new (perceived) material vulnerability; willingness to improve or scale up program/policy ■ Willingness to improve governance model	Document review, academic literature, interviews, observation
	Political economy	■ Creating economic-based policy instrument: incentive, fine	Document review, academic literature, interviews, observation
	Social action	■ Response to community	Document review, academic literature, interviews, observation
	Risk perception	■ Understanding stakeholders' perceptions (associated with their culture, political interests, institutional strategies) about risk on peatland to influence collective decision of target group on risk	Document review, academic literature, interviews, observation

Table B1 | **The Types of Linking Mechanisms and Actions in the Governance Cycle Framework and Its Data Collection Method (Cont'd)**

ASPECT	CATEGORY	DESCRIPTION/EXAMPLE OF ACTION	DATA COLLECTION METHOD
Landscape governance: network-institutional arrangement	Institutional arrangement for and beyond peat hydrological unit (PHU)	■ Suitable network governance to support effective planning and implementation of risk management and communication on restoration ■ Division of tasks and responsibilities ■ Provisional mechanism for coordination/ cooperation, across sector/ministry and administrative level	Document review, academic literature, interviews, observation
Risk assessment	Detailed vulnerability assessment per PHU	■ Preassessment: problem framing, concern assessment ■ Risk appraisal: vulnerability assessment, estimation of risk, estimation of hazard	Document review, academic literature, interviews, (field) observation
Risk evaluation	Verification of result of risk assessment, with participative approach	■ Risk characterization ■ Weighing trade-offs (environmental and socioeconomic benefits; local acceptance), preparing restoration plan ■ Prioritization (of restoration location)	Document review, academic literature, interviews, (field) observation
Risk management	Implementation of integrated PHU-based restoration	■ Identify risk handling options/restoration activities ■ Investigate (potential) impacts, multicriteria analysis ■ Realization of the most preferred option	Document review, academic literature, interviews, (field) observation
Monitoring and evaluation	Tracking progress, impact, result, and evaluation of restoration	■ Observing the progress/effects, ex ante/ex post evaluation	Document review, academic literature, interviews, (field) observation and measurement
Risk communication	Adjusting language/ communication strategy based on culture, political interests, institutional strategies	■ Distinguish hazard and risk ■ Specify exposures and potential vulnerabilities ■ Describe the uncertainties and probability of risk ■ Provide clear justification for risk-handling action	Document review, academic literature, interviews, (field) observation

Source: Adapted from Simon and Dooling 2013.

APPENDIX C. LIST OF INTERVIEWEES

Number	Institution	Date
1	Deputy of Planning, Peatland Restoration Agency (BRG)	May 6, 2019
2	Deputy of Construction, BRG	May 29, 2019
3	Directorate of Management of Environmental Degradation, Ministry of Environment and Agroforestry	June 17, 2019
4	Wetlands International Indonesia (WII)	May 28, 2019
5	Provincial facilitator, Deputyship of Education, BRG	May 21, 2019
6	Provincial Peatland Restoration Agency (TRGD)	May 20, 2019
7	Department of Environmental and Land (DLHP)	May 20, 2019
8	South Sumatra Forestry Agency (Dishut)	May 22, 2019
9	South Sumatra Development Planning Agency (Bappeda)	May 21, 2019
10	Public Works and Water Resources Agency, South Sumatra (PUPSDA)	May 17, 2019
11	Agriculture and Plantation Agency, South Sumatra (Disbun)	May 23, 2019
12	Natural Resources Conservation Agency (BKSDA) KLHK	May 22, 2019
13	Indonesian Palm Oil Association (GAPKI)	May 22, 2019
14	South Sumatra Environment and Forestry Research and Development KLHK (Balitbang KLHK)	May 21 and October 14, 2019
15	Watershed Forum, South Sumatra (Forum DAS)	May 23, 2019
16	Hutan Kita Institute (HaKI; local NGO)	May 23, 2019
17	Zoological Society of London (ZSL), Indonesia	May 21, 2019
18	Community in Pedamaran, Ogan Komering Ilir (OKI) Regency, South Sumatra	July 15, 2019
19	Community in Air Sugihan, Banyuasin, South Sumatra	July 11, 2019
39	Head of village Muara Sungsang, Banyuasin Regency	October 18, 2019
21	Head of subvillage IV, Menang Raya, Pedamaran, OKI, South Sumatra	July 17, 2019
22	Gading Cempaka Graha company	July 18, 2019
23	Head of neighborhood 10, village Menang Raya, OKI, South Sumatra	July 17, 2019
24	Head of village Menang Raya, OKI, South Sumatra	July 17, 2019
25	Purun Institute	July 16 and October 16, 2019
26	Head of subdistrict Pedamaran, OKI, South Sumatra	July 15, 2019
27	Environmental agency, OKI	July 15 and October 17, 2019
28	Village empowerment agency, OKI	July 16, 2019
29	Farmer group	July 16, 2019
30	Village facilitator, BRG	July 13, 2019
31	Professor Rudjito, Sriwijaya University (UNSRI)	October 15, 2019
32	Eko S., governor's special staff	October 15, 2019
33	Benni, DLHP South Sumatra	October 15, 2019
34	Farmers on peatland, OKI	October 16 and 17, 2019
35	Purun weavers in OKI	October 14 and 16, 2019
36	Manager of Perseroan Terbatas (PT) Rambang, OKI	October 17, 2019
37	Plantation and Animal Husbandry Agency, OKI Regency (Disbunnak OKI)	October 17, 2019
38	Pelayanan Terpadu Satu Pintu (PTSP) agency, South Sumatra	October 18, 2019
39	Deputy of Education, BRG	September 3, 2020

APPENDIX D. PEATLAND-RELATED MEETINGS AND EVENTS

Events	Date	Subject /Context	Organizer
NGO consortium (KPRGSS) meeting with the BRG	January 9–10, 2019	Reporting draft of restoration plan in 6 peatland hydrological units in South Sumatra	BRG and KPRGSS
NGO consortium meeting	January 25, 2019	Preparing publication and joint research from restoration plan document	KPRGSS
Peat expert workshop in Palembang	January 29–30, 2019	Synergy of research and development on peat management	Kelola Sendang and Tropical Forest Alliance
Public consultation of detailed restoration plan	February 7, 2019	Consulting stakeholders about the result of restoration plan	KPRGSS and BRG
Meeting to synergize fire prevention and controlling activities	March 2019	Involving related provincial stakeholders in South Sumatra	Dishut
Peatland restoration sites in Ogan Komering Ilir and Banyuasin Regencies, South Sumatra	July 2019	Checking rewetting infrastructures; canal blocking	Wetlands International Indonesia
Meeting to synergize efforts on fire control in South Sumatra	October 2019	Reporting progress of works from different stakeholders in fire control/prevention	BRG and South Sumatra government

APPENDIX E. THE GAP BETWEEN PLANNING AND IMPLEMENTING RESTORATION IN SOUTH SUMATRA, 2017–2019

Restoration activities	2017		2018				2019	
	Plan	Implementation	Plan			Implementation	Plan	Implementation
Implementing agencies	BRG and partners		BRG and partners	Concession holders[c]		BRG and partners	BRG and partners	
				10 industrial forest plantations	14 oil palm plantations			
Canal blocking (unit)	5,868	0	6,972	2,081	878	544	1,343	257
Canal backfilling (unit)	144	10	165			18	0	0
Revegetation (hectares)	213,352	82[a]	64,592			3	10,589	0
Livelihood revitalization[b] (unit)	0	11	82			26	0	0

Notes:

[a] Data from BKSDA and Forestry Agency of South Sumatra, not recorded by the BRG.

[b] These projects include the provision of livelihood supports/aid such as demonstration plots and/or farms for dryland crops and fisheries. They are managed by local farmer groups and are supposed to be self-sustaining, but some are found unsustainable due to floods and other reasons (see Box 2).

[c] In concession areas, the BRG provided technical assistance about restoration for concession holders in 78,397 ha of peatland, but all were located in eight oil palm plantations and none in industrial forest concessions due to coordination issues with the KLHK (BRG 2020a; Nugraha 2020).

APPENDIX F. SELECTED PHUS, VILLAGES, AND THEIR RESTORATION ACTIVITIES

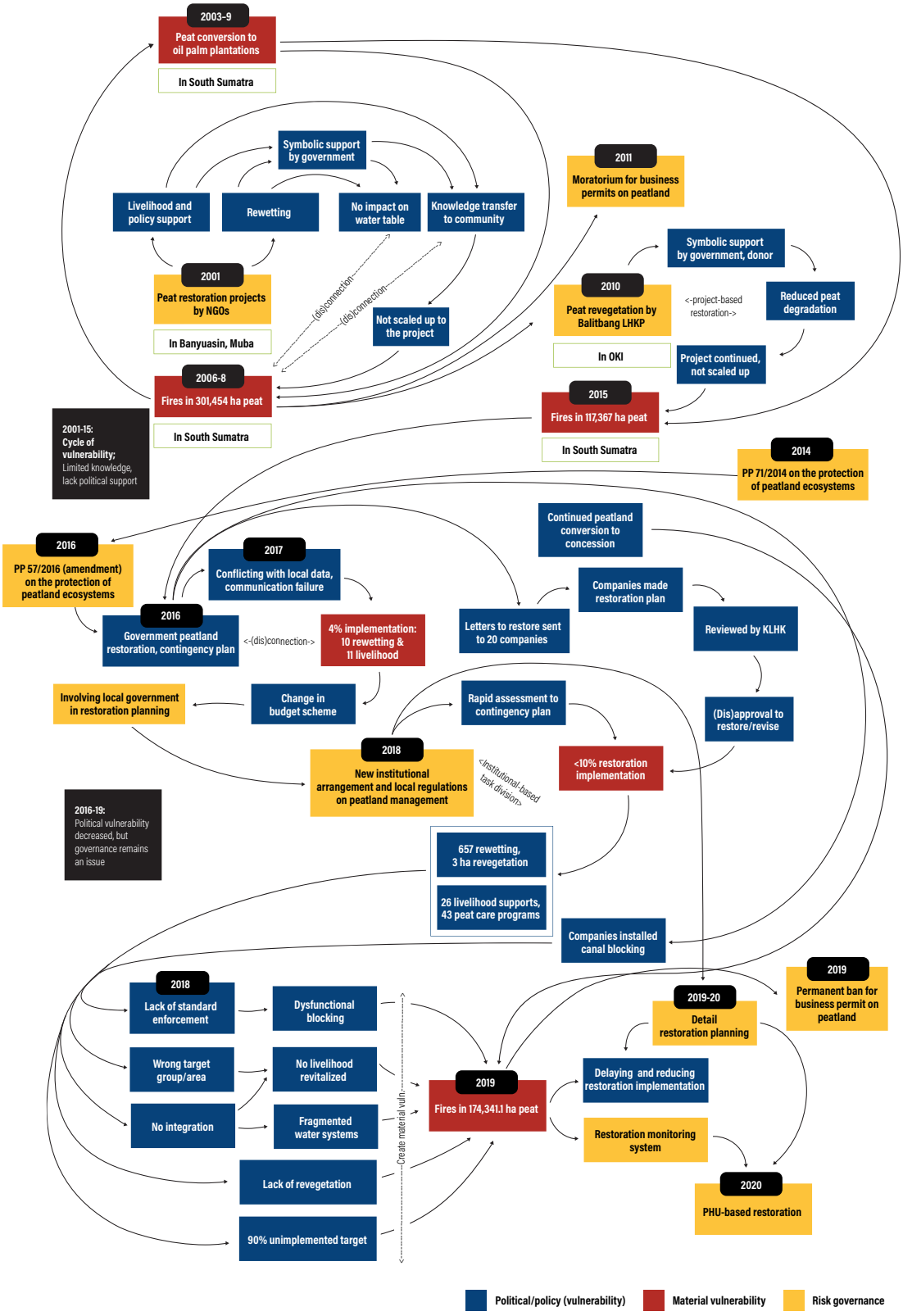
Peatland Hydrological Unit	Village	Peatland Size[a] and Condition[b]	Socioeconomic Context	Restoration Activities	Implementing Agencies
Saleh-Sugihan	Banyubiru, Simpang Heran	4,766.29 ha Land cover/use: swamp-shrub, plantation forest, rice field, settlement area, and a small area of estate crop plantation	Dominated by transmigrant community, mostly working as farmers	Canal blocking	BRG, water resources agency, community groups
Lalan-Merang Ngirawan	Merang-Kepayang, Muara Medak	65,624.56 ha Land cover/use: bare land, estate crop plantation, plantation forest, savannah, secondary swamp forest, and a large area of swamp-shrub	Dominated by native people, mostly working in agriculture and forestry	Canal blocking, livelihood revitalization	NGOs, BRG
Sugihan-Lumpur	Riding, Lebung Itam, Lebung Gajah, Simpang Tiga Sakti	223,616.04 ha Land cover/use: bare land, bush/shrub, estate crop plantation, plantation forest, and a large area of swamp-shrub	Dominated by native people, some working for concession areas	DPG	BRG, NGOs
	Padang Sugihan	46,742.96 ha Land cover/use: bare land, small area of estate crop plantation, fish pond, rice field, savannah, settlement area, and a large area of swamp-shrub	The area is surrounded by 16 villages, which often put pressure on the area	Canal backfilling (2017)	BRG, BKSDA
Burnai-Sibumbung	Kedaton, Sepucuk, Kayuagung	1,783.49 ha Land cover/use: bare land, estate crop plantation, plantation forest, secondary dryland forest, and a large area of swamp-shrub	Mix of transmigrants and native people, working for subsistence agriculture and oil palm plantations	Rewetting, revegetation, livelihood revitalization (2010)	Balitbang LHKP, BRG
	Cinta Jaya, Sumber Hidup, Pedamaran, Menang Raya	48,637.96 ha Land cover/use: bare land, plantation forest, shrub-mixed dryland farm, and a large area of estate crop plantation and swamp-shrub		Canal blocking, livelihood revitalization, DPG (2018)	BRG, NGOs, concession holders

Notes:

[a] The extent of peatland in the observed village.

[b] Based on early available data, before the field observation/ground truthing of this study. Land cover/use in most of the areas is dominated by the estate crop and swamp brush.

APPENDIX G: THE GOVERNANCE CYCLE OF PEATLAND RESTORATION IN SOUTH SUMATRA, 2001–2019



APPENDIX H. SPATIAL DISTRIBUTION OF BURNED PEATLAND AREAS, 2019

Total burned peatland area: **174,341.10 ha** (Burned concession area: 93,900.63 ha; burned nonconcession area: 80,440.47 ha)			
Newly burned area on peatland		Recurrent burned area on peatland	
Concession	Nonconcession	Concession	Nonconcession
92,749.47 ha	29,289.30 ha	1,151.16 ha	51,151.17 ha
Total newly burned area on peatland: 122,038.77 ha (70% of total burned area)		Total recurrent burned area on peatland: 52,302.33 ha (30% of total burned area)	

Note: Burned area data in the table is from UMD n.d.,Appendix I. The Governance of Risk Management on Peatlands in South Sumatra, 2001–2015: Restoration versus Conversion to Plantation

APPENDIX I. THE GOVERNANCE OF RISK MANAGEMENT ON PEATLANDS IN SOUTH SUMATRA, 2001–2015: RESTORATION VERSUS CONVERSION TO PLANTATION

	Adoption/Adaptation of Risk Governance	***Political Vulnerability***	***Linking Mechanisms***	***Material Vulnerability***
2001–5	Adaptation of risk assessment and risk management (canal blocking and introducing alternative livelihoods to peatland community)	Absence of an integrated landscape approach, not based on peatland hydrological unit	Fragmented restoration activities per village did not lead to fully rewetted/restored peatland ecosystem	■ Peat soil did not fully rewet, thus still prone to fires ■ Anthropogenic pressures remained, thus peat still prone to slash-and-burn practices
2002–8		Project-based management on restoration activities	Absence of knowledge transfer among projects/ institutions affected the quality of restoration activities	14,818 ha of restoration area suffered from recurrent fires in 2006–8
2002–10		Peatland conversion to oil palm and logging concessions	Plantation concessions created intensive drainages/ canals that degraded peat	Plantation drainage decreased water table and drained peat, thus still prone to fires
2006–14		Combination of abovementioned political vulnerabilities	Area of peatland conversion to plantations was far larger than restoration area	Recurrent fires from 2006 to 2014; 1 million ha peat degraded[a]
2014	Issuance of Government Regulation No. 71/2014 on the protection of peatland ecosystems			
2015				117,367–144,410 ha peat burned in 2015, with 6,580 ha in villages in or near former restoration and conservation areas; emitted 0.05 GtC and air pollutants (301 ug/m^3); caused more than 30,000 cases of respiratory illness

Note:
[a] Tribunnews.com 2015.

APPENDIX J. VULNERABILITY IN THE GOVERNANCE OF RESTORATION IN FOUR PHUS IN SOUTH SUMATRA

PHU	Villages	Risk Governance	Political Vulnerability	Material Vulnerability[a]
Saleh-Sugihan	All villages in PHU (4,766.0 ha of the area targeted for restoration)	■ Detailed restoration planning was completed by the end of 2018 ■ Risk management: canal blocking, livelihood revitalization	The 2018 restoration implementation was based on the contingency plan and rapid assessment	29,167.2 ha burned peat in 2019
	Banyubiru, Simpang Heran	Canal blocking, livelihood revitalization	Absence of ground truthing in planning caused rewetting to be implemented in nonpeat areas	Budget wasted
Sugihan-Lumpur	All villages in PHU (228,378.0 ha of the area targeted for restoration)	■ Peat care program ■ Canal backfilling, livelihood revitalization	No ground truthing in the restoration plan	25,672.6 ha peat burned in 2019
	Riding, Lebung Itam, Lebung Gajah, Simpang Tiga Sakti	Peat care program	■ No rewetting and revegetation activities in these villages ■ Peat care programs across villages not integrated	14,113.4 ha burned in 2019
	Padang Sugihan	Canal backfilling, livelihood revitalization	Absence of ground truthing in planning caused restoration to be implemented in nonpeat areas	Budget wasted
Lalan-Merang Ngirawan	Muara Medak (33,104.0 ha of the area targeted for restoration)	Canal blocking, livelihood revitalization	A technical error in canal blocking construction[b]	8,512.6 ha burned peat in 2019
Burnai-Sibumbung	All villages in PHU (39,445.0 ha of the area targeted for restoration)	Rewetting, revegetation, livelihood, peat care programs	■ No ground truthing/socioeconomic survey in the restoration plan ■ No integration among activities in the PHU	Approximately 3,504.0 ha burned peat in 2019
	Kedaton	■ Rewetting, revegetation, livelihood revitalization ■ Paludiculture as risk management adapted	Paludiculture principles not fully adopted	3,215.0 ha peat burned in 2019, including 50% of the project area
	Cinta Jaya, Sumber Hidup, Pedamaran, Menang Raya	Risk management adapted; canal blocking, livelihood revitalization, peat care program	■ Proper rewetting not done in the whole PHU ■ Livelihood revitalization not achieved because livelihood supports delivered to nonpeat-dependent communities	1,700.8 ha burned peat in 2019
	Concession areas	Canal blocking, revegetation	Low-quality canal blockings, disintegrated positioning	1,713.9 ha burned peat in 2019
The four PHUs	305,693.0 ha of the area targeted for restoration	Rewetting, revegetation, livelihood, peat care programs	Absence of landscape approach and dysfunctional institutional arrangements	58,728.3 ha burned peat

Notes:
[a] The burned areas are in areas targeted for restoration.
[b] Wijaya 2019a.
Source: WRI Indonesia authors.

APPENDIX K. THE GOVERNANCE OF PEATLAND RESTORATION IN SOUTH SUMATRA, 2016–2019

	Adoption/Adaptation of Risk Governance	Political Vulnerability	Linking Mechanisms	Material Vulnerability
2016–17: restoration in two peatland hydrological units (PHUs)	Adaptation of risk assessment for planning restoration activities	■ Failure in understanding stakeholder's perceptions about risk; not having common ground on restoration approach ■ Absence of collective institutional arrangement ■ Absence of detailed planning/ risk assessment and evaluation	Local stakeholders did not fully support the centralized restoration approach/plan	Restoration plan was not fully implemented; peatlands remain degraded and prone to fires
2018–19: restoration in six PHUs	■ Adaptive governance arrangement ■ Risk assessment and evaluation ■ Risk communication ■ Local regulations on peatland protection	Rent-seeking behavior	Fragmented implementation of restoration activities	Restoration was implemented without landscape/PHU approach; not optimum impact
	Risk management: canal blocking, revegetation	Absence of implementation of integrated landscape/PHU approach for restoration activities	Fragmented restoration activities per village did not lead to fully rewetted/restored PHU	Restoration activities had limited impact; some peatlands remain degraded and prone to fires
	Canal blocking (rewetting)	Lack of standard enforcement to quality of restoration activities	One out of five canal blockings were dysfunctional a few months after construction	Water table is not significantly increased; peatlands remain degraded and prone to fires
	Risk management and communication: livelihood and education for peat-based communities	■ Overlapping/disintegrated livelihood supports in livelihood revitalization and peat care programs ■ Some livelihood supports were not delivered to the peat-based groups	The livelihood of peat-based communities was not revitalized/ shifted	Anthropogenic pressures on peat remain; thus, peatlands are still prone to fires
	Restoration plan in concession area	Long bureaucracy process for concession holders to implement proper restoration	Bureaucracy time took two to three years; it caused peat degradation to continue	Peatlands remain degraded and prone to fires
2019	Peatland Restoration Information Monitoring System (PRIMS)	Combination of abovementioned political vulnerabilities	Exacerbated by El Niño	■ 139,084–174,341 ha peat burned in 2019; emitted 0.062 GtC and air pollutants (232 ug/m^3) ■ 274,502 cases of respiratory disorders

Source: WRI Indonesia authors.

APPENDIX L. FOUR STEPS IN THE SECOND PHASE OF DATA COLLECTION

1. On the provincial scale, we gathered and analyzed data on general vulnerability in the governance of peatland restoration in terms of its institutional arrangements, coordination dynamics, restoration activities, and impacts. Information on restoration activities and the extent of burned peatland area were collected and analyzed via tabular and spatial data from imaging sensors (Moderate Resolution Imaging Spectroradiometer [MODIS] and Visible Infrared Imaging Radiometer Suite [VIIRS]), the BRG's open-source PRIMS[55] web application, and the KLHK's Fire Monitoring System.[56]

2. We selected four PHU samples in the province: PHU Sugihan-Lumpur and PHU Burnai-Sibumbung in the OKI Regency[57] PHU Lalan-Merang Ngirawan in the Muba Regency, and PHU Saleh-Sugihan, which covers parts of both the OKI and Banyuasin Regencies. The OKI, Muba, and Banyuasin Regencies are priority restoration areas in South Sumatra and suffered the most from the 1997 and 2015 fires.
   - The selection of these PHUs considered the diversity of restoration activities in the area in terms of their type, the time of planning and implementation of the activities,[58] and the different implementing agencies working in the area (Figure 6). Nonforest areas and conservation areas are priority restoration locations in South Sumatra (Wijaya 2017).
   - For each PHU, we gathered and analyzed detailed information on governance practices for restoration (to assess political vulnerability), on-the-ground implementation (to assess linking mechanisms), and the progress and impact of the restoration activities (to assess material vulnerability).

3. In the four PHUs, we selected between two and four villages for observation (Appendix F).[59] The selected villages are at different stages of restoration planning and implementation activities (rewetting, revegetation, revitalization of livelihoods, and DPGs). This variability enabled us to capture lessons learned about the characteristics of activities and the temporally- and spatially-adaptive learning in the restoration governance among villages.

4. We then analyzed and synthesized the findings from the PHUs and confirmed with provincial stakeholders whether they aligned with experiences in other PHUs in South Sumatra. This was confirmed through a second round of interviews with provincial stakeholders and academics.

APPENDIX M. THE PEATLAND RESTORATION INFORMATION MONITORING SYSTEM (PRIMS)

PRIMS[60] was established to track current peatland conditions and monitor the progress of restoration activities and their impacts. Data displayed on the platform are official, public information sourced from the BRG and its partners. PRIMS uses the newest peatland map, which was updated by the Ministry of Agriculture in 2019; it has a 1:50,000 scale that is much more accurate and precise than its former data.

The BRG developed this platform with World Resources Institute (WRI) Indonesia; the Agency for the Assessment and Application of Technology (Badan Pengkajian dan Penerapan Teknologi); the Food and Agriculture Organization of the United Nations; the United Nations Development Programme; the United Nations Office for Project Services; and the Partnership for Governance Reform (Kemitraan untuk Pembaruan Tata Pemerintahan), a local NGO.

PRIMS follows the principle of inclusive and participative monitoring and evaluation in risk governance, where peatland restoration actors from government bodies, NGOs, civil society organizations, and private sector actors can contribute in data collection for monitoring. This supports the coordination, cooperation, and adaptive learning process among institutions in synergizing restoration efforts within PHUs.

APPENDIX N. AN EFFORT TO SUSTAIN PEATLAND RESTORATION IN SEPUCUK, OKI REGENCY

In the early 2000s, the GoI allowed around 23,000 ha of peatland to be converted to commercial forestry in Kayuagung District. Following logging, about 1,743 ha of peatland burned in 2006. Much of the burned area was then converted to oil palm plantations. Just 20 ha in the district were scheduled for restoration later in 2010, located in the village of Sepucuk (Wijaya 2019b).

The KLHK's research institute, Balitbang LHKP,[61] was appointed as the implementing agency for the 20 ha restoration project using revegetation. The intention was to conserve native species such as *jelutung, ramin,* and *meranti.* However, no canals were blocked at the beginning of the project, even though the canal-blocking technique had been introduced in previous restoration projects in Banyuasin and Muba. The failure to block canals and encourage rewetting reduced the effectiveness of the restoration (Budiman et al. 2020a).[62] The failure can be attributed to the project's limited resources[63] and the absence of knowledge transfer across projects, which in turn resulted from the fragmented implementation of restoration during the 2000s.

The restoration project in Sepucuk was supported by local government and international organizations, but it was not scaled up to other degraded peatlands in South Sumatra because no national framework for peatland restoration existed in 2010. The project was scaled up later in 2017 as part of the restoration in PHU Burnai-Sibumbung.

GLOSSARY

Canal backfilling: Closing/covering canals in degraded peatland ecosystems to stop the dry-season drawdown, thus retaining water in the system, raising the water table, and keeping the peat wetter.

Canal blocking: Blocking canals in degraded peatland ecosystems to slow the rate of dry-season drawdown, thus retaining water in the system, raising the water table, and keeping the peat wetter for longer.

Concession area: Space or land granted within or upon a premise that is used for the purpose of a subsidiary business (plantation/logging).

Contingency plan: The first planning document used for national peatland restoration activities in 2016/17.

DPG (Desa Peduli Gambut; Peat Care Village) program: A program to educate the community about peatland conservation and to support village officers in mainstreaming peatland restoration into village policies.

Material vulnerability: Unintended consequences such as fire hazards, GHG emissions, and reduced quality of life resulting from the inability of stakeholders to deal with these complex socio-environmental problems.

Moratorium: A temporary prohibition of the granting of permits to concession holders.

Paludiculture: Agriculture, forestry, or agroforestry on wetted peatlands using native species and/or species adaptive to acidic peat, without drainage.

Political vulnerability: The inability of policymakers and stakeholders to deal with the complexity of socio-environmental problems.

Rapid assessment: An alternative method for restoration planning, when a detailed restoration plan or engineering design is not yet ready.

Rewetting: Activities to rewet degraded peatlands. It is done by blocking or backfilling canals on degraded peatlands to raise the water table.

Revegetation: Replanting trees and/or crops that are native/adaptive in wetted peatlands.

Revitalization of livelihood: Persuading a community to shift to sustainable cultivation on peatland and/or paludiculture or to introduce new livelihoods outside peatlands to reduce environmental pressures on peatlands.

ABBREVIATIONS

Balitbang LHKP	Balai Litbang Lingkungan Hidup dan Kehutanan Palembang (Palembang Environment and Forestry Research and Development Center)
BKSDA	Badan Konservasi Sumber Daya Alam (Natural Resources Conservation Agency)
BRG	Badan Restorasi Gambut (Peatland Restoration Agency)
DED	Detailed Engineering Design
DLHP	Dinas Lingkungan Hidup dan Pertanahan (Department of Environment and Land)
DPG	Desa Peduli Gambut (Peat Care Village program)
GCG	Gading Cempaka Graha
GHG	greenhouse gas
GtC	gigatons of carbon
GoI	Government of Indonesia
ICRAF	World Agroforestry
KLHK	Kementerian Lingkungan Hidup dan Kehutanan (Ministry of Environment and Forestry)
KPRGSS	Konsorsium Perencanaan Restorasi Gambut Sumatra Selatan (South Sumatra Peatland Restoration Planning Consortium)
M&E	monitoring and evaluation
MRPP	Merang REDD Pilot Project
Muba	Musi Banyuasin
NGO	nongovernmental organization
OKI	Ogan Komering Ilir
PHU	peatland hydrological unit
PP	Peraturan Pemerintah (Government Regulation)
PRIMS	Peatland Restoration Information Monitoring System
RREG	Peatland Ecosystem Restoration Plan (Rencana Restorasi Ekosistem Gambut)
RTT	Rencana Tindak Tahunan (Annual Action Plan)
SSFFMP	South Sumatra Forest Fire Management Project (SSFFMP)
TRGD	Tim Restorasi Gambut Daerah (Provincial Peatland Restoration Agency)
WII	Wetlands International Indonesia

ENDNOTES

1 This includes both legal and illegal plantations by private and state-owned companies and smallholders.

2 Authors' analysis using ArcMap by overlaying logging concessions with peatlands, using Datum WGS84 and cylindrical area projection.

3 This area is included in the target restoration areas, which also covers canalized peat domes under concession areas.

4 This includes conversion in nonpeatlands; specific data for peatlands are not available.

5 See the Peatland Restoration Information Monitoring System, https://prims.brg.go.id/platform.

6 Including financial losses from forest fires in nonpeatland areas.

7 The increase in water table levels varies in different areas depending on the peat degradation level, water-holding capacity, porosity, maturity, and vegetation cover. Previous study in Central Kalimantan found the water table was 55 centimeters higher in the forest and 68 centimeters higher in the deforested site after rewetting activities.

8 DPG also supports village officers to mainstream peatland restoration into village policies. Read more in Section 4.2

9 In addition, KLHK is responsible for issuing licenses for most logging concessions.

10 In peatlands, low water tables are caused by ineffective restoration programs and the dry climate of El Niños.

11 Other strategies are also needed to increase the effectiveness of restoration programs, including investment, changes in subsidy structures, and the creation of markets for paludiculture products.

12 The use of native species and species adapted to acidic soils in wetted peatlands for agriculture, forestry, and/or agroforestry.

13 Actionable forms of vulnerabilities within the policy and governance cycle of peatland management.

14 Kompas, Tempo, Jakarta Post, Eco-Business, and Gatra.com.

15 This aims to verify or update the peatland map. The ground truthing checks peatland coverage (existence and depth) and the implementation of restoration.

16 This refers to the upstream part of a river or subbasin.

17 The driver of the project was international pressure and attention to protect carbon-rich peatlands. In 2000, Indonesia did not have a peatland restoration policy.

18 This area is now part of the PHU Lalan-Merang Ngirawan, but the concept of the PHU was not yet introduced in 2001.

19 There are more than two canals in the peat swamp forest.

20 Muba (Pagar Desa, Muara Medak, Kali Berau, Bayat Ilir, and Mangsang villages), Banyuasin (Prajen Jaya, Talang Lubuk, Upang, and Muara Telang), and OKI (Riding, Ulak Kemang, Ujung Tanjung, and Simpang Tiga Sakti).

21 Law No. 39/2014 about granting business permits says that the local government has jurisdiction to grant permits for concessions in its area. The local government sometimes ignored the moratorium policy on permits on peatland.

22 This made it more difficult for restoration to achieve its fire-control objectives.

23 Although the 0.4 m standard may not be adequate for the long term (Evans et al. 2019), many concession holders still objected to it on the grounds that compliance was too difficult. The regulation is, in fact, unclear regarding whether the water table requirement of 0.4 m is an average number or applies to the wet or dry season (Sari 2020). Despite this lack of clarity, several ministerial regulations were still issued to guide peatland restoration activities to meet the 0.4 m requirement.

24 The Muba, Banyuasin, and OKI Regencies.

25 The same issue happened at the national scale, where only 7 percent of the annual target was achieved.

26 The differences between the TRGD and the BRG are exacerbated by internal conflicts between their staffs.

27 Some stakeholders argued that the TRGD might have political motivations for providing economic incentives as 2018 was an election year for South Sumatra's governor. This shows the role that politics plays in risk governance of peatland management.

28 Not only in South Sumatra but also in other provinces.

29 The BRG has the authority to facilitate restoration in conservation areas.

30 By the end of 2018, detailed plans for four PHUs had been developed.

31 According to the BRG's technical guideline, this was supposed to be a Detailed Engineering Design (DED) or Annual Action Plan (Rencana Tindak Tahunan; RTT) for restoration. However, the coordination issue with the TRGD became an obstacle for conducting DED. Rapid assessment is done when DED/RTT is not (yet) in place.

32 This issue also triggered conflict between the head of the TRGD and the DLHP.

33 The deputy argued that the TRGD did not fulfill its responsibility to facilitate cross-institutional coordination in the province. Thus, the deputy coordinated directly with the specific local agency, excluding the TRGD.

34 This is due to long procedures for concessions to prepare the plan as well as bureaucracy at the KLHK, which also requires coordination with the Ministry of Agriculture (for oil palm concessions).

35 Less than the national achievement, which was 18 percent.

36 This rewetting is the main restoration activity to restore peat wetness. It is especially important to conduct rewetting in areas that have been drained, where the conditions are dry and prone to fires.

37 The initial authority arrangement (the BRG for nonconcession areas and the KLHK for concession areas) does not support the landscape restoration approach.

38 Sometimes it appears that the budget for M&E is disbursed to the vendor or contractor even before implementation. In these cases, M&E is not carried out, and implementing agencies often make no effort to force the vendor to comply. There are regulatory issues about the M&E of canal blocking. Nonpermanent blocking is not considered a state asset; thus, its M&E is not mandatory.

39 Many implementations were canceled due to incorrect information provided by the rapid assessment; for example, the assessment showed locations in concession areas that were outside of BRG andTRGD jurisdiction.

40 The former head of the TRGD moved to the Muba Regency government and triggered the formation of a new TRGD in Muba, the first regency-level TRGD in South Sumatra. This may further increase the fragmentation in restoration governance.

41 In April 2019, KLHK Ministerial Regulation No. 10/2019 was issued on the determination and management of peat dome peaks based on PHUs as an effort to protect and manage peat ecosystems, but several articles in the regulation allow existing concession areas in peat domes to continue their operations. This may weaken protections for carbon-rich peat domes.

42 There are 21 groundwater stations in peatland restoration areas in South Sumatra.

43 The European Centre for Medium-Range Weather Forecasts estimated that 0.19 GtC were emitted by Indonesian forest fires in January–November 2019 (ECMWF 2020). These emissions were estimated to be almost double those from the fires in the Brazilian Amazon during the same year (Santoso 2019).

44 The target restoration area also includes canalized peat domes under those concession areas.

45 This includes conversion in nonpeatlands; specific data for peatlands are not available.

46 Updated information about this topic is not available.

47 The conversion may also include the community practice of burning land to prepare it for crop cultivation. Further research is required on this vulnerable action.

48 Although the 2019 El Niño index (Null 2020) was lower than the 2015 index, fires in 2019 were higher. South Sumatra remained the province with the second-highest extent of burned scar area in 2015 and 2019, after Central Kalimantan.

49 This can be integrated with the rural regional development program (Kemendesa 2020).

50 Canal blocking and backfilling must be conducted for the entire PHU, even for canals that are in nonpeat areas.

51 Giesen (2015) provides 514 paludiculture species in Indonesia, including forest and nonforest species.

52 These options depend on local community livelihoods and situations.

53 Undertaking livelihood revitalization activities by cultivating crops with drainage is not in accordance with the principle of peatland restoration even though these activities have economic value for the community. The selection of cultivated species for livelihood revitalization activities needs to consider the principles of peatland restoration or prevention of environmental pressure on peatlands (Medrilzam et al. 2014).

54 This unit is defined by the KLHK (Suwarno et al. 2016).

55 For more information, see the PRIMS website, https://prims.brg.go.id/dasbor.

56 For more information, see the Fire Monitoring System website, http://sipongi.menlhk.go.id/home/main.

57 An administrative unit below the provincial level.

58 We selected PHUs that had different times of implementation (e.g., 2002, 2010, 2017, and 2018). This criterion is important to identify the existence of adaptive learning among the activities.

59 The village sample was limited because we had limited access to some villages.

60 See the PRIMS website, https://prims.brg.go.id/dasbor.

61 For more information, see the Balitbang LHKP website, https://www.bpk-palembang.org/.

62 During this period, knowledge was lacking about the minimum requirement for the water table in rewetting efforts.

63 Human and financial resources.

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ABOUT WRI

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We envision an equitable and prosperous planet driven by the wise management of natural resources. We aspire to create a world where the actions of government, business, and communities combine to eliminate poverty and sustain the natural environment for all people.

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COUNT IT

We start with data. We conduct independent research and draw on the latest technology to develop new insights and recommendations. Our rigorous analysis identifies risks, unveils opportunities, and informs smart strategies. We focus our efforts on influential and emerging economies where the future of sustainability will be determined.

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We use our research to influence government policies, business strategies, and civil society action. We test projects with communities, companies, and government agencies to build a strong evidence base. Then, we work with partners to deliver change on the ground that alleviates poverty and strengthens society. We hold ourselves accountable to ensure our outcomes will be bold and enduring.

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